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ABSTRACT

Reported is a longitudinal study on changes in affective attitudes for the purpose of determining the effectiveness of a 1971-72 innovative guided design course. In the pretest-posttest control group design, the experimental group was composed of chemical engineering juniors, and the control groups were junior students in civil or industrial engineering. Affective variables included: (1) student's perception of himself and his surroundings, (2) debilitating and facilitating anxiety, (3) internally-oriented characteristics, (4) achievement motivation, and (5) understanding of engineering function. Osgood's semantic differential, Rotter internal-external locus of control scale, the Edwards personal preference schedule achievement scale, the achievement anxiety test, and an engineering function questionnaire were used as instruments. Practicing engineers answered the same questionnaire to ascertain differences in their operational procedures. Significant differences were noted in perception of the importance of communications as compared to mathematics and science and in such concepts as "engineer," "future goal," and "change." The remaining variables manifested changes in the preferred direction. The experimental group become more internally controlled. The guided design course was satisfactory. Recommendations were made on further research on noted trends. (CC)

FINAL REPORT

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Morgantown, West Virginia 26506

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ABSTRACT

A new course structure, entitled Guided Design, is gaining notable attention in engineering education. A major reason for this attention is the promise the course pattern holds for influencing student affective attitudes, in addition to its emphasis in the cognitive domain. The present project used paper & pencil instruments to examine changes in student attitudes in a time-dependent longitudinal fashion as a result of taking a two-semester sequence of a Guided Design course.

Significant differences in the preferred direction were noted for the experimental group as compared to the other engineering control groups. At $\alpha=0.05$, the experimental group had a greater change in their perception of the importance in engineering of communications as compared to math and science, and in their perception of the semantic differential concepts 'engineer', 'future goal', and'change'. At $\alpha=0.16$, a relative improvement in debilitating anxiety was noted.

Changes in the preferred direction were noted for the experimental group for facilitating anxiety and understanding of the engineering function. The experimental group individuals tended to become more internally controlled.

These results are interpeted to mean that the experimental Guided Design course does positively influence students in the affective domain.

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The author is indebted to Dr. M.S. Tseng for his assistance and guidance on this project. The author appreciated the able assistance of Mr. J. S. Duggal in analyzing the results.

INTRODUCTION

Increasingly, people in our culture are searching for a greater relevance and understanding in their work, in their education, in their lives. As a consequence, in engineering education the adoption of freshman design courses has occurred in most engineering schools in the country; new design courses are being instituted into the senior year,[1,2,3,4] and in selected universities design work is being incorporated into all four years of the engineering curriculum.[5,6] In particular this course work is expected to motivate the student and give him at the earliest stage of his education a more comprehensive understanding of the functioning of an engineer.

New course structures such as PSI[7,8,9] are being instituted to improve the efficiency of teaching the theoretical concepts and uses of engineering. In general these new course styles also provide for concern with social relevance, while maintaining or increasing levels of content learning.

A course sturcture gaining notable attention is Guided Design,[10] as it combines the self-study aspects of PSI with the emphasis on design. This course style is being used at West Virginia University; Fairmont State College, Wright State University, Younstown State University, and University of Michigan. In addition at least three other institutions are considering adoption of this course pattern in some of their courses. A major reason for the attention and promise of the structure appears to be that this course pattern has a strong influence on affective attributes[11] in addition to its successful treatment of learning activities in the cognitive domain.[12] The present study was undertaken to determine the extent to which affective factors might be affected by the Guided Design course structure.

Project Objectives

One objective of the present project was to examine changes in student affective attitudes in a time-dependent longitudinal fashion as a result of taking a two-semester sequence of a Guided Design course.

Historically, the engineering education community has been primarily concerned with students' cognitive learning and dealt with the issues of course design and evaluation in that connection. However, engineering educators increasingly are becoming more aware of the importance of taking into consideration affective aspects in course designs.[13,14] A pioneering effort by Korn and Wise[15] looked at the interaction of affective variables and college success. For a narrow range of high ability students, they found no correlation between academic performance and intellectual aptitudes.[15]. Instead, a variety of attitudes and affective variables accounted for most of the variability in a student's academic performance. Thus recent course designshave incorporated the theory of educational psychology for affective learning. But little has been down towards quantifying the effectiveness of these new affective designs. To the quthor's knowledge the only previous longitudinal study of changes in affective characteristics conducted on college engineering courses was conducted on a freshman Guided Design course.[16]

This project was also undertaken to provide pilot data, especially with respect to affective learning, for the evaluation of engineering education curriculum. The Department of Chemical Engineering, West Virginia University, is initiating a new curriculum utilizing Guided Design and other innovative features.(6) An in-depth evaluation of this curriculum is being conducted as it is being developed. In contrast to many published papers on the theory of curriculum evaluation, there have been very few experimental studies in the literature of the effectiveness of new curricula.(17)

Course Structure

The modified version of the Guided Design structure was presented in Thermodynamics and Kinetics, a chemical engineering 2-semester course sequence (3 credits per semester). It differed from most Guided Design courses in that little written feed back on design projects was given, as oral feedback was extensively used.

To enhance the student attributes of independence, self-image and self-control over his environment, the students were asked to self-study programmed texts and then to work on assigned engineering problems. About 60-70% of the required problems were correctly done by the students on their first try. The instructor corrected and guided this work towards successful completion of the problems by writing extensive comments on the homework. The students reworked the problems until they satisfactorily completed all the homework. For each section of assigned homework, there was a test. Upon completion of the homework as indicated above, the student was eligible to take the exam. He had the option of retaking the exam to improve his grade.

A rigorous, but respectable, work load was required. About 60-80 problems/semester were to be worked by the students. Forty (40) other more difficult problems were available for extra credit toward their grade. (This compares to 80 required problems for a physical chemistry course also being taken by the students at the same time.(18)) The homework was expected at about two-week intervals. The intent was to encourage students to pace their day-to-day work.

Open-ended design projects were included to develop an inclusive picture of the course content while modeling the framework of a working professional. Guidance was given in a formal strategy approach to projects. It uses applications to encourage thinking in preference to a formal course to abstractly teach problem-solving and thinking.(19) A total of 7 projects were used during the year. Students were required to work in groups of 4-6 to enhance the ability to work in a group and get along with fellow student professionals. The projects also served the cognitive goal of developing student intellectual and comprehensive problem-solving skills.

The instructor devoted class time in allowing the students to progress on projects or to discussing the homework or the class progress on the project. The course therefore differed from conventional courses in the amount of interpersonal interactions, the emphasis on feedback and practicality, and the design projects which were to stimulate higher cognitive thinking.

Complete details of the course structure are presented in Appendix I. An example of a student group report on a project is presented in Appendix II.

Choice of Evaluation Insturments

Five affective variables were examined in this study.

The student's perception of himself and surroundings is an important determinant in his ability to work with others and to be satisfied with his own work. A general instrument to tap these perceptions, with respect to key concepts such as peers, instruction, is the Osgood's Semantic Differential.[20] It was conjectured that the course format, which requires students to work closely with his peers, and have close interaction with the instructor, might change s student's perception of his environment. If a change in a concept perception is noted in the positive direction, improvements in satisfaction level and ability to work in groups might be supposed.

The course utilized an exam procedure which mandated preparatory homework. The student was then ready to take the exam at the mutual convenience of the student and instructor. Coupled with no exam time restrictions and the practice of using the best exam of an optional two exams for each section of material, the anxiety level of the student might well change. Debilitating anxiety should be lowered while test performance increases. The instrument used to examine this hypothesis was the Achievement Anxiety Test,[21] which yields both debilitating and facilitating anxiety measures.

If a student is successful with the self-study features, increased feedback to the students in problems and projects, and exam procedure, he might be expected to increase his feeling of control of his situation and become more internally oriented. An internally-oriented individual, who believes positive and negative events are the consequences of his own acts, tends to have a higher level of work proficiency and more favorable personal qualities (ability to work with others, self-reliance, courtesy and work tolerance).[22] The modified Rotter Internal-External Locus of Control was chosen to examine this characteristic.[23]

According to achievement-motivation theory,[24] students with high achievement motivation do more and better work when positive accomplishment is a result of diligent effort. A moderately difficult task seems to provide the best motivation. If too difficult a task is presented, the student gives up; if too easy a task is presented, the student does not feel challenged and does not expend sifficient effort. A major modification concerns a person's fear-of-failure; for individuals they may have a tendency to be predominantly achievement- or fear-motivated.[24] Engineering is noted for the rigor of its discipline, and the emphasis on solution of many problems. Engineering education appears to fulfill many aspects of achievement motivation theory. It appears to be a strong self-adjusting system, obtaining Ss with high achievement motivation. The increased emphasis on design in the present experimental course, coupled with set goals and a number of problems of various difficulty, would seem to meet the criteria of achievement-motivation theory for high accomplishment ratios for students. It might be possible to produce a change in affiliation motivation itself with a designed course structure.

More likely, achievement motivation will be high and perhaps be a factor in affecting changes in the variables, student perception (Osgood's Semantic Differential) or locus of control (Rotter Internal-External Locus of Control).

One important feature of successful engineers is their approach to their job.(25) Such factors as reliability, general knowledge of technical concepts, willingness to assume a large work load, are critical.(25) To be successful, the engineer should be aware of these factors. The factors are affective, i.e. to manner in which the individual operates, but are based on cognitive knowledge of both technical concepts and working conditions. One expects that established engineers would have different perational procedures than do student. to ascertain these differences, a questionnaire was constructed and administered to practicing engineers, and subsequently to the students.

One other domain of obvious importance is ambiguity tolerance. In practical engineering situations, often the solution, or even the problem itself, are very unclear and ill-defined. Yet the engineer must work as best he can. In most curriculums, a student generally uses only small, straight-forward textbook problems. The development of tolerance for ambiguity is an important need. The use of more complex projects with various alternative solutions should help the student progress in this engineering trait, although it is difficult to modify this trait. A separate experimental program is being pursued to analyze the progress of students through a 4 year curriculum utilizing large projects. This program will analyze the development of technical concepts and ambiguity tolerance.

METHODOLOGY

A pretest-posttest control group design was used to study change in affective variables over the time period of one academic year. The experimental conditions of limited student enrollment dictated that the experimental group be composed of juniors in chemical engineering at West Virginia University enrolled in a required course sequence 1971-72. The control groups were West Virginia University students enrolled in civil or industrial engineering junior-level required courses. The civil and industrial engineering curriculums called for no courses in a format radically different from traditional engineering methods. In 1972-73, all students in engineering at W.V.U. will have been exposed to a Guided Design freshman course similar to the present experimental course format, so the study cannot be directly replicated at W.V.U.

Instruments

The instruments used were Osgood's Semantic Differential, Rotter Internal-External Locus of Control Scale, the Edwards Personal Preference Schedule-achievement scale, the Achievement Anxiety Test and an Engineering Function Questionnaire especially constructed for this study.

The Rotter Instrument is a 29 item, forced choice instrument. It was scored by summing the number of checked external items to give a raw numerical score for each student.(23) Total average values for the group pretest and posttest scores could be compared, as well as average changes for individuals.

The EPPS instrument consisted of a 28-item forced-choice quiz.(26) The standard scoring key supplied with the instruments was used to add the number of n-achievement items checked. An average group score for the pretest and posttest was then determined.

The AAT instrument was a multiple-choice, 19 item test.(21) Nine items concerned facilitating anxiety, ten items were concerned with debilitating anxiety. Each item received a value of 1 to 5 for the choice checked, and was indicative of the apparent anxiety level. The facilitating and debilitating anxiety scores were summed separately. The change in score for individuals were then determined, and an average change for the group calculated.

The Osgood's Semantic Differential was a six-scale instrument, two scales each for 'evaluation,' 'potency' and 'activity' dimensions. The concepts presented on a seven-point bipolar adjectives scale were 'change, thinking, engineer, future goal, instruction, peers.' A preliminary study in 1970-71 also used the word concepts, 'aspiration, socialization, education, instructor, achievement, failure or environment.' A score of 1 to 7 was given for each of the 6 bipolar adjectives scale as the checked item varied from negative to positive for a given word concept. Individual and group concept scores were then compared over the given time period. Net raw scores for all concepts could also be compared for an overall indication of attitude.

The Engineering Function questionnaire was composed by the author and Dr. M. S. Tseng, College of Education, West Virginia University. It was a 19 item (4) multiple choice questionnaire. The items were drawn from the author's experience and published data on engineers' preceptions. A preliminary version of 22 items was distributed to engineering professors and working professionals for them to complete. Based on the analysis of their responses, 3 items were dropped and most of the remianing items were reworded. This questionnaire was sent to 20 industrial organizations with provisions for 3 different practicing engineers to fill out separate questionnaires. Their summative responses formed the basis of the analysis of the student responses. A total of 35 responses from practicing engineers were utilized. If an item choice received 16 or more responses, a value of 4 was assigned to that choice for scoring purposes, for 11-15 responses a value of 3 was assigned, for 6-10 responses a value of 2 was assigned, and a value of 1 was assigned if there were 0-5 responses for a given item choice. Net raw scores for individuals could then be obtained from this key for the questionnaire as a whole. Group scores for specific items could also be analyzed.

Administration of Instruments

The experimental group completed the Engineering Function, Osgood's Semantic Differential, Rotter Internal-External Locus of Control and Edwards PPS-achievement scale on August 26, 1971. The control industrial engineering group completed the instruments EPPS-achievement scale and Engineering Function during the week of September 6, 1971.

A subsequent pretest to start the second semester was completed by the experimental group on January 5, 1972. The instruments were the Achievement Anxiety Test and Osgood's Semantic Differential. A junior civil engineering control group completed the instruments on January 6-7, 1972.

All posttests were completed during May 1973. The experimental group and civil engineering control group completed their respective instruments the week of May 1-4, 1972. The industrial engineers completed the instruments over the last two weeks of May, 1972.

A pilot program was accomplished during the academic year 1970-71. The Osgood's Semantic Differential and Achievement Anxiety Test were used. A civil engineering control class took the pretest during the 2nd week in September, 1970 and the posttest during the 2nd week in January, 1971. The experimental group of chemical engineers took the pretest on September 28, 1970 and the posttest the last week of the semester, December 4-8, 1970.

Statistics

Chi-square and statistics were utlized. The equivalence of variances for pretest and posttests were determined by F-tests. The null hypothesis about equivalence of scores between groups (and pre vs. posttest) were checked by t-tests. Chi-square was used for checking differences between groups (pre vs. post treatment) on individual items in the instruments.

RESULTS

Need for Achievement

The n-achievement scores and changes in the tested groups are recorded in Table I. the null hypothesis examined is as follows:

"There is no difference in the gain during the academic year on EPPS n-achievement between the experimental group and the control group."

Table I
Student Scores on the Edwards Personal Preference Scale-Need for Achievement

	N	Mean N-ach. Score Pretest	Mean N-ach. Score Posttest	Gain Mean	Gain S.D.	
Experimental	15	14.34	14.75	0.41	3.2	
Control	17	16.32	17.75	1.43	4.6	t = 0.70
EPPS-College Males	760	15.66 (Variance = 17.1)				$t_{(\alpha=0.05)} = 2.04$

The t-test value is not significant, the null hypothesis is not rejected. The EPPS n-ach. has not been significantly affected for the experimental students in their junior year as compared to the control students.

Semantic Differential

The student's percetions of the concepts, change, thinking, engineer, future goal, peers, and instruction were analyzed through Osgood's 7-scale, 6 bipolar word pairs for changes in responses as compared to a civil engineering student group. Average scores for each concept are presented below for experimental, control and a reference group. Engineering students have the most positive perceptions for the concepts "thinking" and "future goal". They are least positive towards "peers".

Table II
Average Student Score for Tested Concepts on Osgood's Semantic Differential

Group	No. of Subjects	Instruction	Peers	Change	Thinking	Engineer	Future Goal
Experimental Aug. 71	16	31.1	30.3	31.1	34.1	31.5	32.7
Experimental Jan. 72	16	31.3	29.8	31.0	34.5	31.5	33.5
Experimental May 73	16	31.3	29.6	32.1	34.2	31.1	32.7
Control Sept. 70	12	33.0	29.5	32.2	34.7	34.2	36.9
Control Jan. 71	12	31.6	27.9	29.9	35.2	32.9	35.4
Control Jan. 72	19	34.7	30.0	31.8	36.0	34.5	37.2
Control May 72	19	33.6	29.7	32.0	35.7	34.2	35.5
Reference Seniors Jan. 71	9	32.9	31.9	32.7	36.5	35.2	36.8
Exp. Pilot Aug. 70	17	32.9	31.0	32.8	36.4	33.3	35.0
Exp. Pilot Dec. 70	17	31.0	31.8	30.6	33.4	32.5	33.6

A chi-square analysis was conducted between experimental and control groups comparing the number of students who changed their perception of concepts on the semantic differential in a positive or negative direction. If the score for an individual did not change, the result was excluded from this analysis. The null hypothesis may be stated: "There is no difference between the experimental and control groups in the number of students who changed their perception score on a semantic differential concept."

Table III
Chi-Square Values for Number of Changes in Concept Perception Scores*

Comparison	Engineer	Instruction	Peers	Change	Thinking	Future Goal
(A)	4.20	1.48	0.03	1.06	0	1.63
(B)	0.01	1.36	2.67	0.15	0.15	0.01
(C)	3.47	1.16	0.44(-)	0.20	1.41(-)	0.20

X^2 (α = 0.05) = 3.84
X^2 (α = 0.10) = 2.71

(A) Experimental Group Aug 71 Jan 72
Control Group Sept. 70 - Jan. 71
(B) Experimental Group Jan. 72 - May. 72
Control Group Jan. 72 - May 72
(C) Pilot Experimental Group Aug. 70 - Dec. 70
Control Group Sept. 70 - Jan. 71

*The experimental groups had more changes in the positive direction than the control groups, except for the values marked (-) in which more students changed in positive direction for the control groups.

The null hypothesis was rejected for comparison (A), "engineers" concept. At slightly less confidence, at approximately $\alpha = 0.10$, the null hypothesis was rejected for comparison (B), "peers" concept and comparison (C), "engineers" concept. For these comparisons the alternate hypothesis states: "There is a difference between the experimental and control groups in the number of changes of perceptions of the concept, favoring more positive changes for the experimental groups".

From Table II and Table III one should note that the scores recorded for student perceptions of the selected concepts generally decreased, but that a general trend was noted for the number of control individual to have decreased scores to be greater than the number of experimental group individuals.

A t-test analysis for the average gain in score over the entire 71-72 academic year between the individuals in experimental groups as compared to the net change recorded for the individuals in the control groups was performed. The control group change was estimated by adding the net average change from the two semesters and using the SSII variance from the smaller control group (Fall 1970), as the variance is larger for that group. F-tests on differences in variances were negative.

Table IV
Mean Gain in Score of Individuals in Experimental and Control Groups on Semantic Differential Concepts

Concept	Gain				
	Experimental		Control		t-test
	Mean	S.D.	Mean	S.D.	Value
Future Goal	0	3.23	-3.18	3.65	2.36
Change	1.0	2.71	-2.29	3.66	2.69
Thinking	0.13		-0.15		< 0.5
Peers	-0.63	2.75	-2.03	5.0	0.84
Engineer	-0.38		-1.66		< 1.0
Instruction	0.19	4.00	-2.17	2.65	1.92

$t(\alpha = .05) = 2.05$

The changes for an academic year were determined for the experimental group, 1971-72, while the gain for the control group was estimated from 1970-71 and 1972.

The null hypothesis for this test was: "Over the academic year there is no difference between the experimental group and the control group in the average change in an individual's perception of concepts, future goals, change, thinking, peers, engineer, and instruction as measured by the semantic differential." The null hypothesis was rejected for the changes in the perception of the concepts Change, Future Goal, at $\alpha = 0.05$ level. The alternate hypothesis to be accepted is stated: "There is a difference in the estimated average gain in individual's perception of the concept (Change, Future Goal) between the experimental and control groups, with the experimental group apparently having the change more positive."

One use of the semantic differential is to analyze for gross changes in attitude by taking a total score summed from the responses made to all concepts. A t-test was used to test the null hypothesis:

"There is no difference between the experimental group and control group on change in average total score for all semantic differential concepts over the course of a semester."

Table V
Comparison of Score Summed from all
Semantic Differential Concepts
Between Experimental and Control Groups

	Mean Total Score		Gain		
Comparison	Pretest	Posttest	Mean	S.D.	t-test*
Experimental Group Jan. 72-May 72	191.8	191.5	-0.3	13.0	$t < 1.0$
Control Group	205.8	201.2	-4.6	11.7	
**Pilot Experimental Group Sept. 70-Dec. 70	397.1	378.6	-18.5	7.85	$t = 4.06$
Control Group	392	387	-5.3	6.65	
Senior (Reference)	202				

$t_{(\alpha=0.05)} = 2.06$

*F-test for difference in variance of change = 2.02 ($F_{\alpha=0.05} = 2.72$).

** Includes the additional concepts Environmental, Instructor, Aspiration, Achievements, Socialization, Education.

The null hypothesis is accepted for the spring semester 71-72, but is rejected for the fall semester 70-71. The net score for all concepts decreased more for the experimental group than for the control group in the fall semester 70-71.

Achievement Anxiety Test

Both facilitating and devilitating anxiety were investigated. The analysis of the AAT instrument is presented in Table VI. The t-tests were used to check the null hypotheses:

"There is no difference in the change in debilitating anxiety between the experimental and control groups in the 2nd semester 71-72.

"There is no difference in the change in facilitating anxiety between the experimental and control groups in the 2nd semester 71-72."

The t-tests gave values of t less than $t_{\alpha=0.05}$, the null hypothesis is not rejected.

Table VI
Student scores on debilitating anxiety and facilitating anxiety on the AAT instrument for experimental and control groups, 1971-1972

Group	No. of Subjects	Facilitating Anxiety Mean	Facilitating Anxiety Average Gain	Debilitating Anxiety Average	Debilitating Anxiety Average Gain
Experimental	16	27.0		27.6	
(pre)			2.2 ± 3.3		-1.7 ± 3.65
(post)		29.2		25.9	
Control	19				
(pre)		25.2	1.2 ± 3.3	27.7	0.1 ± 3.55
(post)		26.4		27.8	
			$t = 0.88$		$t = 1.47$
Class 1971 Reference	9	27.3		26.8	
Experimental Pilot	18				
(pre)		26.5	-0.2 ± 4.6	26.4	0.6 ± 4.8
(post)		26.3		27.0	

$\alpha = 0.16$

$(t_{\alpha} = 0.10) = 1.70)$

External-Internal Locus of Control

The experimental group took a pretest-posttest with the Rotter Internal-External Locus of Control Scale over the academic year 1971-72. The results are presented in Table VII, including a t-test of the hypothesis:

"There is no difference in the mean score of individuals between the pretest and posttest."

The hypothesis is not rejected, although a change towards internalization was noted.

Table VII
Average Score of Experimental Individuals
on Rotter I-E

Group	Mean Score*	t-test ($\sigma_1 = \sigma_2$)
Pretest	8.69	1.04
Posttest	7.00	

No Subjects = 13 (One individual's score was eliminated from inclusion by knowledge of student's psychological state when taking the posttest)

*The larger the numerical value, the greater is the external locus of control of the respondent.

Engineering Function

The final form of the instrument, including the scoring key developed from practicing engineers' responses, is presented on the following pages. A comparison of student engineers' and practicing engineers' responses is given on the succeeding pages.

Table VIII
Engineering Function Instrument
Final Form - Scoring Key

A Questionnaire on Engineering

Please read the following items carefully, and then check the action alternative that you believe would be best.

1. As a young engineer with some limited experience, your group leader gives you the month assignment; would you expect your group leader to:

   1 a. explain how to perform the work in detail.
   4 b. be readily available when you have difficulty.
   1 c. check your calculations in detail.
   1 d. ignore you for awhile after explaining your assignment.

2. How would you initially approach a complex design?

   1 a. Estimate the cost of each component.
   3 b. Determine the relative importance of each component in the design.
   1 c. Calculate the size of individual components.
   4 d. Complete the final appropriate balance (mass, energy, force).

3. Which of the following problems best describes a professional problem?

   3 a. Design a non-inductive 500 ohm resistor capable of dissipating 20 kilowatts.
   1 b. Calculate the inductance of a 500 ohm resistor carrying a load of 20 kilowatts.
   4 c. Determine the circuit with a 500 ohm resistance which can effectively carry 20 kw of steady power.
   1 d. Develop a theoretical non-inductive 500 ohm resistor for use in dissipating 20 kw.

4. A friend asks you to specify the skills used most widely by engineers from the following:

   4 a. communications
   1 b. mathematics
   1 c. psychology
   1 d. science

5. As an engineering manager, the most important method of operation in this capacity would be:

   1 a. to require data and logic for your choice.
   3 b. to provide reasoned decisions.
   4 c. to use subordinates wisely and distribute your work to them.
   1 d. to check all the work of subordinates.

6. You are contemplating a career with a large company. If you expect to advance to an executive position, the most probable starting point, as indicated by present executive backgrounds, is:

 1 a. laboratory work
 3 b. finance
 2 c. engineering (design)
 4 d. sales and marketing

7. The difference between a scientist and an engineer might be stated best as:

 1 a. an engineer does, a scientist thinks.
 1 b. an engineer is concerned with the macroscopic, a scientist is concerned with the microscopic.
 2 c. an engineer extrapolates, a scientist deduces.
 4 d. an engineer creates, a scientist examines.

8. In general, what is industry's attitude towards an educational leave of absence so you can learn pertinent new material in a formal study atmosphere?

 1 a. actively encourages one to return to school
 1 b. tolerates more formal schooling
 1 c. discourages one to return to school
 4 d. encourages night courses on your time as a preferred alternative

9. An engineer decides to seek employment with a new company to further his professional career. He should:

 4 a. list a specific job objective, technical qualifications, and a comprehensive personal history.
 1 b. list all the possible jobs he might be interested in and a detailed life history.
 3 c. list the type of job desired and relevant technical qualifications.
 1 d. depict his interest in several jobs and write his friend(s) in management.

10. A friend asks you to state the ability that is most important to industrial professional advancement. It is:

 2 a. dependability
 1 b. knowledge of engineering
 4 c. use of engineering judgment
 1 d. willingness to assume extra work load

11. A friend asks you to state the trait that is most necessary to the perfôrmance of a professional. It is:

- 1 a. knowledge of engineering
- [illegible] b. use of engineering judgment
- [illegible] c. ability to obtain data and information from the literature or experiment
- 4 d. ability to work on a team

12. A job assignment just given to you as a young engineer is "to provide a control system for the X-Y-Z production line." As more information is needed to design the control system, you first:

- 1 a. ask the operating engineer to vary conditions in order to obtain good reliable data.
- 1 b. derive the equations necessary to determine the effect of all parameters.
- 4 c. look at old process operating condition data to find a pattern.
- 2 d. talk to the hourly operators.

13. Your first action as a production unit leader might be:

- 3 a. to improve efficiency by upgrading operation procedure based on the latest engineering analysis
- 1 b. to demand a tight hourly operation schedule for increased efficiency
- 4 c. to work with the hourly operators to develop mutual cooperation
- 1 d. to ask your supervisor for suggestions on how to improve the process efficiency

14. You need to prepare a government proposal on a subject on which you have little knowledge. You first learn about the subject,

- 1 a. by taking a course in the subject
- 2 b. self-study of texts and articles
- 4 c. by calling others in your company or institution who might help direct you
- 1 d. by relying on your research director to give instruction and texts.

15. In preparing for a plant shut-down for periodic maintenance, your strategy is:

- 1 a. parts should be replaced only if fouled.
- 1 b. parts should be ordered to be replaced as they are found defective.
- 1 c. parts should be replaced based on a multi-year master schedule.
- 4 d. an analysis should be made before shut-down to determine all possible trouble spots.

16. Further pilot plant data is needed before a new chemical product can be commercialized. The amount of time that should be planned for would probably be:

    __1__ a. 2-3 months
    __1__ b. 3-6 years
    __8__ c. 3 months - 6 months
    __1__ d. 1-2 years

17. An engineer should be able to work best from a base of:

    __4__ a. broad technical knowledge.
    __1__ b. technical expertise in one area.
    __1__ c. expertise in an engineering science, such as chemistry.
    __3__ d. technology and liberal arts knowledge of a broad character.

18. A professional engineer should concern himself with a list of considerations in the design of a plant unit. The best list from the following is:

    __1__ a. safety, air pollution control, asthetic effects, economics.
    __2__ b. maximum return on investment, society constraints.
    __2__ c. return on investment, flexibility of equipment for the future, safety.
    __4 1__ d. economic efficiency, safety, pollution.

19. Most active engineers stay current by:

    __1__ a. taking refresher courses every few years.
    __1__ b. continuously attending professional meetings.
    __4__ c. maintain their competence through their work.
    __3__ d. independent study.

Comparison of Students and Practicing Engineers

A Questionnaire on Engineering

Please read the following items carefully, and then check the action alternative that you believe would be best.

1. As a young engineer with some limited experience, your group leader gives you the month assignment; would you expect your group leader to:

Ch.E. Students	Engineers		
–	3	a.	explain how to perform the work in detail.
Al	Al	b.	be readily available when you have difficulty.
–	–	c.	check your calculations in detail.
–	3	d.	ignore you for awhile after explaining your assignment.

2. How would you initially approach a complex design?

–	–	a.	Estimate the cost of each component.
Al	1	b.	Determine the relative importance of each component in the design.
–	3	c.	Calculate the size of individual components.
3	2	d.	Complete the final appropriate balance (mass, energy, force).

3. Which of the following problems best describes a professional problem?

2	2	a.	Design a non-inductive 500 ohm resistor capable of dissipating 20 kilowatts.
3	3	b.	Calculate the inductance of a 500 ohm resistor carrying a load of 20 kilowatts.
2	1	c.	Determine the circuit with a 500 ohm resistance which can effectively carry 20 kw of steady power.
2	3	d.	Develop a theoretical non-inductive 500 ohm resistor for use in dissipating 20 kw.

4. A friend asks you to specify the skills used most widely by engineers from the following:

1	1	a.	communications
3	3	b.	mathematics
–	–	c.	psychology
3	3	d.	science

5. As an engineering manager, the most important method of operation in this capacity would be:

3	–	a.	to require data and logic for your choice.
3	2	b.	to provide reasoned decisions.
1	Al	c.	to use subordinates wisely and distribute your work to them.
–	–	d.	to check all the work of subordinates.

The first column presents results for Chemical Engineering second semester juniors; the second column presents results for young practicing engineers from a variety of industrial and government concerns. A code has been established: Al [=] 80-100% reply on this choice; 1 [=] 50-80% reply; 2 [=] 25-50% reply; 3 [=] 5-25% reply; - [=] 0-5% reply.

6. You are contemplating a career with a large company. If you expect to advance to an executive position, the most probable starting point, as indicated by present executive backgrounds, is:

- __–__ __–__ a. laboratory work
- __–__ __2__ b. finance
- __1__ __3__ c. engineering (design)
- __2__ __2__ d. sales and marketing

7. The difference between a scientist and an engineer might be stated best as:

- __3__ __3__ a. an engineer does, a scientist thinks.
- __2__ __3__ b. an engineer is concerned with the macroscopic, a scientist is concerned with the microscopic.
- __3__ __3__ c. an engineer extrapolates, a scientist deduces.
- __2__ __1__ d. an engineer creates, a scientist examines.

8. In general, what is industry's attitude towards an educational leave of absence so you can learn pertinent new material in a formal study atmosphere?

- __3__ __3__ a. actively encourages one to return to school
- __3__ __3__ b. tolerates more formal schooling
- __–__ __–__ c. discourages one to return to school
- __Al__ __1__ d. encourages night courses on your time as a preferred alternative

9. An engineer decides to seek employment with a new company to further his professional career. He should:

- __1__ __~50%__ a. list a specific job objective, technical qualifications, and a comprehensive personal history.
- __–__ __–__ b. list all the possible jobs he might be interested in and a detailed life history.
- __2__ __~50%__ c. list the type of job desired and relevant technical qualifications.
- __3__ __–__ d. depict his interest in several jobs and write his friend(s) in management.

10. A friend asks you to state the ability that is most important to industrial professional advancement. It is:

- __2__ __2__ a. dependability
- __–__ __3__ b. knowledge of engineering
- __1__ __1__ c. use of engineering judgment
- __3__ __3__ d. willingness to assume extra work load

11. A friend asks you to state the trait that is most necessary to the performance of a professional. It is:

- – 3 a. knowledge of engineering
- 2 2 b. use of engineering judgment
- 3 3 c. ability to obtain data and information from the literature or experiment
- 1 2 d. ability to work on a team

12. A job assignment just given to you as a young engineer is "to provide a control system for the X-Y-Z production line." As more information is needed to design the control system, you first:

- 3 3 a. ask the operating engineer to vary conditions in order to obtain good reliable data.
- 3 3 b. derive the equations necessary to determine the effect of all parameters.
- 1 1 c. look at old process operating condition data to find a pattern.
- 3 2 d. talk to the hourly operators.

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- 2 2 a. to improve efficiency by upgrading operation procedure based on the latest engineering analysis
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3	1	c.	3 months - 6 months
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18. A professional engineer should concern himself with a list of considerations in the design of a plant unit. The best list from the following is:

-	-	a.	safety, air pollution control, asthetic effects, economics.
3	3	b.	maximum return on investment, society constraints.
3	3	c.	return on investment, flexibility of equipment for the future, safety.
1	1	d.	economic efficiency, safety, pollution.

19. Most active engineers stay current by:

-	-	a.	taking refresher courses every few years.
2	3	b.	continuously attending professional meetings.
3	2	c.	maintain their competence through their work.
1	2	d.	independent study.

The individual questions were each analyzed for validity as test items. Items 9, 11, 19 had the least clear-cut commonality of engineers' attitudes. Item 17 is suspect, as present data is different from previous published data.

In Table IX are the results on the students' average total score according to the previously detailed key. A t-test of the difference in gain between the two groups is included, and found to be not significant.

Table IX

Comparison of Group Mean Total Scores for Individuals on the Engineering Function Instrument

Group	Mean	Gain	Gain S.D.	t-test
Experimental, Pretest	40.60			
Experimental, Posttest	43.40	2.80	6.53	
Control, Pretest	40.67			0.80
Control, Posttest	41.33	0.66	6.55	

The individual items were analyzed by chi-square statistics for differences in number of responses marking the preferred response (value 4) and all other responses (value 1-3) for the group comparison:

A) Experimental, Pretest - Posttest
B) Control, Pretest - Posttest
C) Experimental Pretest - Control Pretest
D) Experimental Posttest - Control Posttest

These comparisons are listed in Table X for those changes which were largest. If a chi-square value is not given for a change for a given item, the value was not significant and considered negligible.

Table X
Chi-Square Values of Comparison of Preferred and Nonpreferred E.F. Responses-Selected, Large Value Responses

Group	Item	X^2 Value	(X^2 = 3.84, α = 0.05)
Experim. Pretest-Posttest (Posttest, Larger Value = +)	4	3.34 (+)	
	8	5.4 (+)	Significant
	13	1.29 (+)	
	15	0.49 (+)	
	16	2.40 (-)	
Control Pretest-Posttest (Posttest, Larger Value = +)	13	2.40 (+)	
	15	5.62 (-)	Significant
	16	1.66 (+)	
Experim. Posttest - Control Posttest (Experim., Larger Value = +)	4	8.88 (+)	Significant
	8	8.88 (+)	Significant
	15	1.29 (+)	
	16	0.68 (-)	
Experim. Pretest - Control Pretest (Experim., Larger Value = +)	4	0.68 (+)	
	8	0.12 (+)	
	13	0.55 (+)	
	15	2.25 (-)	
	16	3.97 (-)	Significant

An interesting comparison is how individuals with external or internal locus of control in the experimental group fared on engineering function attitudes. Taking a cut-off of ICEC score = 7, a comparison was made between external and internal individuals for final mean value on the engineering function and mean gain for individuals.

Table XI
Control of Mean Final Score, Engineering Function and Mean Gain, Engineering Function as a Function of Locus of Control

No. of Subjects	Locus of Control	Mean	S.D.	t-test	Gain	S.D.	t-test
7	External	45.3	6.9	1.345 (α = 0.20)	5.5	7.3	1.055 (α = 0.32)
6	Internal	40.5	4.5		1.0	6.7	

The experimental program has a tendency to help external individuals achieve greater insight into the attitudes of professional engineers.

DISCUSSION OF RESULTS

A restriction in this study was the constrained choice of groups(Type I error) and the limited number of subjects. However, within this limitation several significant results were obtained, and generally positive trends for the experimental group were noted as compared to the trends in the control group.

This pioneering effort of a longitudinal study of variables in the affective domain has also demonstrated some important characteristics of engineering students. The EPPS n-ach mean score is not significantly different from that of all college males (norm provided by the publisher of EPPS). Upper level engineering sutdents perceptions of concepts (instruction, peers, thinking, engineer, future goal, and change) as measured by an Osgood's Semantic Differential, tend to remain fairly constant or perhaps more perceptions become negative than become positive.

Need for Achievement

The EPPS instrument chosen for measuring n-ach has been shown to include items measuring intrinsic need for achievement and fear of failure to approximately equal weight[27], i.e. fear of failure at assigned tasks is measured as well as the inner drive to be successful in a task. There has been little correlation with the EPPS instrument with indirect or projective measurement of n-ach. In fact, the observed tendency of persons having high EPPS n-ach scores to avoid immediate risk is as if they were in fact more strongly motivated to avoid failure than achieve.[27] This finding appears to agree with the facts that (i) the experimental group had a decrease in debilitationg anxiety (D.A.), while the control group had a negligibly small change in D.A. and(ii) the EPPS n-ach mean score for the control group was larger than that of the experimental group, but were non-significant. The only conclusion that should be made is that engineering students have approximately the same mixture of need-for-achievement and fear-of-failure as do most college males.

Semantic Differential

From Table II we note that engineering students do have some feelings about concepts that have been traditionally assigned to them. They are most positive about "thinking" and task-oriented "future goal" and least positive about "peers", probably due to a lesser degree of affiliation motivation.

The number of negative changes in perception of concepts was significantly greater for the control group for "engineer", while the net average gain for the concepts, "future goal" and "change" were significantly greater for the experimental group at α=o.05 and the concept "instruction" was greater for the experimental group at α=o.07. In general the control group had negative changes in concept perceptions, while the experimental group had a relatively constant perception of concepts relative to engineering and engineering settings.

Previous studies have concentrated on finding correlations between student personality patterns and the Semantic Differential.[20,28] It would seem that the meaning of the measured concepts either increased in clarity or remained clearer in the students' minds in the experimental group as compared to the control group. It can be conjectured that the experimental course provided greater insight into concepts during a stressful time in their collegiate careers. However, it is difficult to interpet the results, in light of the possible uncertainity of meaning being measured by the semantic differential.[29] The present author agrees with this latter idea on the uncertainity of the meaning being measured, especially in light of the contrdictory results of the pilot program.

The pilot program was conducted the previous year during the fall semester. For the basic concepts used in the research program, little difference was noted between the experimental and control groups (Table III). However, with the six additional concepts tested in the pilot study, the changes were more negative for the experimental group than the control group. A net 'summed' score for all concepts was obtained for each group, and can be used to obtain a qualitative sense of the positive or negative state of the groups at the time of the testing. As the pilot program had a significant decrease in the summed score for the experimental group as compared to the control group, the experimental group might be supposed to have changed negatively. As the posttests were taken at different times for the two groups, the experimental group may have been begative because of impending pressure of final exams. In addition the workload for that semester was particularly high compared to other semesters, and this may have caused negative feelings. It would seem important to remember thsis difference in posttests, and not attach particular reference to a statement about the experimental course.

<u>Achievement Anxiety Test</u>

Both the experimental and control groups gained in facilitating anxiety over the course of the academic year. There was no significant difference, although the gain was larger for the experimental group. At α =o.16, it was shown that the debilitating anxiety decreased for the experimental group as compared to the mean for the control group.

It has been found that the AAT strongly correlates with academic performance.[21] A negative correlation exists for debilitating anxiety, while a positive correlation exists for facilitating anxiety. Most other anxiety measures do not show such correlations.[30] Using these measures, it was found that there was some effect between anxiety and success with programmed learning and between anxiety and level of intellectual ability. The work by Denny[31] showed that highly intelligent students performed better and less intelligent students performed porrer if the students were highly anxious as compared to students with less anxiety but the same abilities. In general the results for programmed learning have been inconclusive, and one can state that it appears both high and low anxiety students learn equally well form programmed material.[30] This is an important point as programmed learning is the major method of content knowledge acquistion in the experimental course.

The present results and discussion agree with the argument that the testing procedure, using multiple tests after ascertained preparation on homework problems, will reduce undue test-taking anxiety and increase performance. The results are rather remarkable when one considers the limited sample size and that this is only one course out of five or six taken by the junior students.

Internal-External Locus of Control

There was a definite shift toward the internal direction for the experimental group, although not a significant increase at the 0.05 level. These results are in the same direction as the significant difference found for a freshman Guided Design course (Tseng and Wales, 16). The students control much of the environment in the course, as they help choose a test time, and they were in charge of the designs with a fair degree of freedom as to the type of answers. Thus during class time they were expected to perform classwork, but at their own leisure and pace. The change in the internal direction would therefore seem likely. Guided Design courses appear to increase the desireable trait of internalization of locus of control. This trait is desireable as internals are more cooperative, self-reliant, courteous, and have a greater work knowledge and tolerance for work load.[21]

Engineering Function

There was an overall increase in the understanding of the functioning of engineers by junior level students, but the increase was not significant (Table IX). Partly this is due to the fact that many of the attributes of the method of operation of engineers is already understood by the junior students (in both the experimental and control groups).

The instrument developed in this study was a good one, but further refinement would provide for an excellent general questionnaire on the professional attitudes of engineers. In addition to the items 9, 11, 17, and 19 discussed in the Results, items 16 and 18 would require improved item statements. Two items, 6 and 8, were primarily investigating industry attitudes. A questionnaire on Professional Attitudes of strong validity that could be utilized at present is one composed of items 1,2,3,4,5,7,10, 12,13,14, and 15.

In examining Table X, one concludes that the experimental group made significant strides compared to the control group on (Item 4) understanding the improtance of communication as compared to science and mathematics, and on (Item 8) knowladge of industry's attitude about continuing education. These results can be attributed to the emphasis made in the experimental Guided Design course on written reports and group discussions in connection with engineering design. This emphasis is lacking in traditional engineering courses. Conversely, on Item 15 the industrial engineering control students initially had an excellent knowledge of strategy to use in maintenance and shut-down but lost it over the course of the year. A manifestation of time of presentation of procedures and practice in maintenance and scheduling is the most likely explanation of this result. Industrial engineering emphasizes this aspect of engineering in their curriculm, while it is usually ignored in chemical engineering.

An interesting comparison on professional functioning of engineers between external and internal students was obtained in Table XI. A large gain in knowledge of engineering functioning was obtained by external students. It would appear that the group dynamics of the Guided Design course encourages these students to learn the professional attitudes emphasized in the course.

The present analysis is concerned with measuring a trai which contains both the cognitive and affective domains. Previous work with courses utilizing programmed instruction has assumed programmed instruction teachs independent thi-king and judgement.(32,33) Mixed results have been obtained. The present course assumes that the best results are obtained in the formalized training through design projects. The attitudes of students towards an approach to complex problems requires a significant length of time.(34) A portion of the attitudes can be measured by questionnaire, and these attitudes have been tapped by the present instrument. The fact that a single experimental course caused increased gains in a positive direction in these traits is highly encouraging.

General

It is important to note that the experimental group had significant differences in gains, or at least gains in the preferred direction, in the four affective areas examined: Perception of Concepts (Osgood's Semantic Differential), Internal-External Locus of Control, Debilitating and Facilitating Anxiety, and Understanding of the Functioning of an Engineer. As noted previously, the results on Need for Achievement are ambiguous, because of the inappropriateness of the instrument. Previous work has indicated subjectively the same or slightly improved knowledge in content and the cognitive domain.(12) Such positive results lead a pragmatist to say, "This Guided Design course looks good; let's keep developing it as it appears to offer considerable improvement in dealing with the modification of certain affective characteristics of engineering students."

CONCLUSIONS AND RECOMMENDATIONS

Improtant significant differences in the preferred direction were noted for the experimental group as compared to the control groups with respect to (i) perception of the concepts "engineer","future goal", and "change" at $\alpha=0.05$ and "instruction" at $\alpha=0.07$, (ii) change in debilitating anxiety at $\alpha=0.16$, and (iii) change in student perception of the importance of communications as compared to math and science at $\alpha=0.05$. Changes in the preferred direction were also noted to be greater for the experimental group on other semantic differential concepts, facilitating anxiety, and understanding of the functioning of engineering in general. The experimental group also tended to become more internalized. The sum of these results may be interpeted that the experimental Guided Design course does positively influence students in the affective domain and should be considered as an improvement in course design.

Continuing effort should be made on substaniating or finding significant results for the noted trends. In particular, it is recommended that further work be performed with

(i) Achievement Anxiety. It appears that student anxiety can be changed, and thus academic performance can be improved by the correct test procedures. Substaniated results would be very noteworthy for educational design.

(ii) Internal-External Locus of Control. As students improve their concept of self-determination, more productive engineers and students would be trained. The idea of a course design enhancing this trait is important to education.

(iii) Professional Attitudes. Documentation of improved results in creating a professional attitude in students is very important, as this is one of the chief goals of Guided Design philosophy. In particular it would be important to test these changes over 4 years of college.

These recommendations are already being partially implemented in subsequent studies by the author on I.C.E.C. and Professional Attitudes.

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Course Structure and other Descriptive Materials of Course

COURSE STRUCTURE

Ch. E. 142 -- Thermodynamics

Preface:

This course will be a semi-self-paced course of a problem-oriented nature. The text will be "Programmed Thermodynamics", which is designed for your participation in learning and studying the material in this course. Explanations and definitions of concepts are clearly presented in detail in the text; therefore, almost no time will be spent in class lecturing on those points. Instead, thermodynamic design problems will be solved during class as the most efficient utilization of time to help you learn this most important skill.

There will be five sections of the course. A section problem set will be due before you are allowed to take the corresponding exam. The exam should be taken at a mutually designated time any time up to the section deadline (see attached course section timetable). Nominally the exam is scheduled for one hour; however, extra time will be available if you so desire. Exams will require the use of design principles.

This course will use many problems from Physical Chemistry, either directly or modified, to show the relationship between Engineering Thermodynamics and Chemical Thermodynamics. The two are obviously very similar in structure; however, engineers emphasize flow (open) systems and use material property diagrams much more extensively than the chemist. Hopefully, a greater appreciation of this relationship will allow for mutual reinforcement and enhancement of your performance in both chemical engineering and chemistry.

The emphasis on design problems in class is to help you work towards becoming a good chemical engineer. The ability to do design work is the distinguishing mark of an engineer. Design is more than the calculation of equipment size; in its broad context, it is the synthesis of a new solution to a given problem by the application of all the appropriate facts from the many laws and data available.

Organization:

An outline of the course is presented (Table I) to indicate the progress you should be making in this course. In actual fact, most of the content will be learned by you through self-study of the text. There will be little pressure for class preparation on a day-to-day basis; you must use self-discipline in order to succeed in this course. The object of this differently paced course is to teach thinking and design skills in Thermodynamics, and in this process, learn more content material.

Thus, the class will be divided into design groups of 4-6 people, who will then work together on assigned tasks. The professor's job is to encourage and guide you through the self-learning process of performing a design task. I will be available for consultation if I am free (see my card at my office, Room 417). Please do feel free to drop in on me, whether to check on the design problems in the Programmed Text or on the problem sets.

The grading of the course will be somewhat different than you may have encountered previously. I would expect that most students who proceed on time can obtain a B; in particular, the problem sets should be done and redone (based on my directed guidance) until you have correctly submitted the problems. The procedures that will be used are outlined in the following.

Grading:

There will be two types of problems on the homework -- standard problems involving the more simple intellectual skills and asterisk problems involving more of the higher level intellectual modes.

The exams will be divided into two parts, a standard exam and a performance exam. These two parts correspond, respectively, to the standard problems and the asterisk/design problems. The standard exam will only be graded complete or incomplete. It will be patterned after the self-quiz questions and answers at the conclusion of each chapter in the text. The performance exam will be graded two ways -- completed number of problems and performance points which will include partial credit. A typical question might be to list the important considerations in a design similar to that done in class.

The grade criteria necessary to guarantee one's grade is as follows:

Table 1

Criteria	Grade
1. All standard problems and standard exams completed.	C
2. Criteria 1 + completion of 3 asterisk problems/section (Total = 15) and 3 problems on the performance exam completed. Active participation in the design projects is required.	B
3. Criteria 2 + 300 performance points. Asterisk problems completed over and above criteria 2 will be worth 3 performance points each. Credit will be given to the group members for the design project (60 points available).	A
4. Standards not met (completed).	F

"Completion" of a problem means that the problem was done in a correct manner. There are about 80 standard problems and 45 asterisk problems in the course structure.

Exams will be open book. There will generally be 2-4 standard exam problems and 1-3 performance problems on the exam. The number of performance points will vary according to the listings in the course schedule (total = 400). Extra time is available for this exam. A typical good performance exam score will be 60-70%.

Problems may be submitted as often as desired until the problem is "completed", except for deadline provisions: If the initial submittal of a problem occurs after the deadline, it will be graded only once. Initial problem submittal should include evidence of effort expended on the problem. Resubmittal of a problem must include the original problem and instructor comments. An asterisk problem may be substituted for a standard problem. Half-credit for performance points will be awarded on initial submittal of an asterisk problem, if deserved.

In order to take the exam, <u>all</u> standard problems for that section must be completed. Standard exams may be retaken until passed, at your direction, after a three day wait. A second performance exam part may be taken for each section; the highest score will be the score used in the final evaluation. If the exam is initially taken after the deadline date, only 2/3 credit will be given. This implies the necessity of the completion of one more standard exam problem.

If anyone cannot meet standards because of deadline dates -- come to see me to work out special arrangements/assignments.

If anyone is sick or has specific problems, special time extensions are available.

Table 2 -- Course Section Outline

Section	Deadline: End of Class Design and Problem Set	Deadline: Exam
(Exam Points)		
I Chapter 1-3 (50)	Sept. 8	Sept. 18
II Chapter 4-6 (100)	Oct. 4	Oct. 18
III Chapter 7-9 (50)	Oct. 20	Oct. 27
IV Chapter 10-12 (100)	Nov. 12	Nov. 20
V Physical Equilibrium,	Dec. 8	Dec. 17
Hand-Outs (100)		

The standard exam must be passed before the performance exam may be taken in a given section.

You may proceed ahead on the problem sets and exams as fast as desired; in fact, you are encouraged to finish early if possible. Once you have finished all section exams, course attendance is no longer mandatory. You are still free to retake any exam, however. The final exam period will be available for anyone that desires to take an examination.

A good reference text for Physical and Chemical Equilibrium is K. G. Denbigh, the Cambridge Press, "Principles of Chemical Equilibrium". Problem solving can be aided by the pocket book, R. J. Bearman and B. Chu, Addison-Wesley, Problems in Chemical Thermodynamics.

COURSE STRUCTURE

Ch. E. 143 --Kinetics

Stucture:

There will be homework assignments made at least once a week. They will be graded and then discussed during the next period or two. Two design reports will be completed during the course of the semester.

There will be two types of exams given; one type is a Problem Exam and the other type will be a Design Exam. The Problem Exam will contain three problems of the minimum standard problems that must be accomplished successfully, and one more difficult, challenging problem. The Design Exams will requie the use of design principles in a new situation, and may be based in part on the above-mentioned design reports.

Course Grading:

	Graded by Instructor	Expected Level for Grade C	B	A
Homework	Standard Problems	50% #	50%	50%
	Performance Problems	–	50%(avg)	50%(avg)
	Each problem will be graded on 0, 1/2, 1 scale only)			
	#-Student will redo new problem set until this level reached.			
Design Reports		Acceptable*	Acceptable	Honors (avg)
	* - Student will redo reports until acceptable.			
Problem Exams		60% #	80%*	80%
	#-Each exam section must be retaken until 60% scored.			
	* - Exam may be retaken once to improve score if passed initially. If failed initially, a grade of 60% is entered upon passing, unless a second grade greater than 80% is obtained, in which case the latter score is entered.			
Design Exams		Minimum	Minimum	Honors(avg)

Content Materials:

Chemical Equilibrium, Author, WVU Faculty

PLCRE (Programmed Learning Chemical Reaction Engineering), R.S. Fogler, University of Michigan

To: Junior Ch. E. Students
From: Dr. John T. Sears

Thermodynamics and Kinetics

As a teacher, I would like to see you depart from this course with some very real gains in your educational development. These developmental goals can be listed and explained in the following three educational goals:

1. To provide material which makes it possible for each student to demonstrate that he can recall, manipulate, translate, interpet, predict and choose the appropriate Thermodynamic or Kinetic concept in problem solving.

These six intellectual skills are the necessary framework in order for you to solve a given problem. Recall is the most basic, and it is the one with which you are most familiar. Manipulation of equations, extrapolation of curves are specific examples of these skills. The specific skills and concepts you should learn in this course are listed at the end of the chapters in the text. The standard problems and exams explained in the accompanying course description are given so you can practice to perfection these intellectual skills.

2. To provide course work which demonstrates what chemical engineers do and to provide practice, and to demonstrate how he can interact to provide a better society so people can live better lives.

The choice of design problems and/or consideration of social constraints was made to remind you of this important criterion if we are to provide a happier, more tolerant world for ourselves and our children.

3. To provide experience in the primary function of a college education: for a student to think for himself logically, to learn to gather for himself all necessary information, communicate ideas and use the three intellectual modes of analysis, synthesis and evaluation.

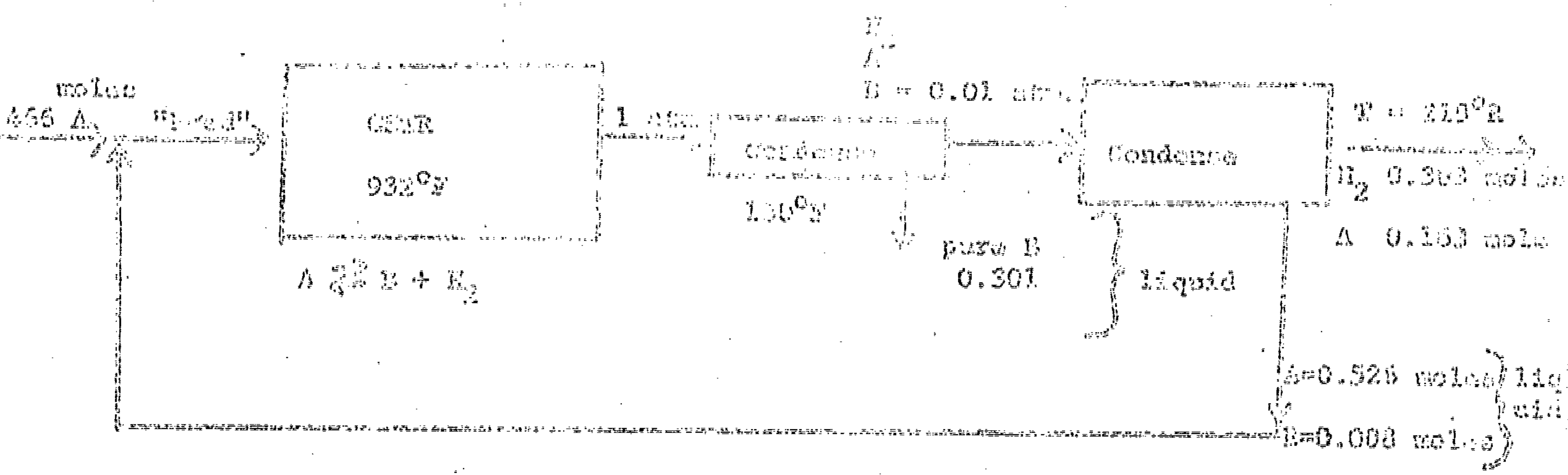
The use of design problems, and multi-skilled problems requiring the use of the intellectual modes, described as performance and asterick problems, are included in this course to enhance your intellectual achievement through the use of the three intellectual modes. Although not emphasized in this course, I feel that clear, concise communication of well-thought ideas is one of the best examples of the use of intellectual modes in an open-ended problem.

The third goal was listed last because it is the most important goal. The intellectual skills are needed in order to operate in an intellectual mode, but is is these latter abilities which mostly determine your future success. The intellectual abilities stay with you when the transitory knowledge fades. "Education is what is left after you have forgotten the facts."

[illegible]

On the last project, it was suggested that an improved system to produce B from A might be:

$X_{eq} = 0.303$



Basis: 1 mole Feed
Constant Pressure in Gas Streams = 1 atm.

The sale price of B is now given as \$4/mole, and the price of A is \$2/mole. The price of H_2 is 7¢/mole. The cost of cooling was given as a function of cooling T. It can be given approximately constant $1 \times 10^{?}$/yr. The operating cost for the reactor was \$1.18 $\times 10^5$/yr for a production rate of $8 \times 10^{?}$ moles/yr.

3. Assume now the information which led to the second condenser being chosen to operate at 219°R was inaccurate, and the vapor pressure A information should be VP = 0.70 atm at 100°F, and $\Delta H_{vap\ A}$ = 10,000 Btu/mole. What would now you recommend as the operating conditions of the system? No inert should be added. What is the profit?

4. If the reaction producing B were actually slow so equilibrium is not reached in the reactor, but X(conversion) is only 0.20, indicate what might be the effect on increasing or decreasing reactor and condenser equipment sizes. What process conditions might be changed - condenser temperatures, mole flow rates? Quantitative numbers are not desired, but a discussion of your reasoning.

Appendix II
Examples of a
Student Design Report and a Guided Design Project

Pennville Petroleum Company
Madison, Pennsylvania

Present:

Taped Notes
June 16, 1972

Jerry Alles, Light Hydrocarbon Section Chief
Jim Newman, Trainee Engineer Assigned to Section
Samual O. Shellmer, Design Engineer

Jerry: Jim, you asked yesterday whether you might discuss the separation unit of the Allyl Alcohol Process.

Jim: Yes, there seems to be something amiss in the driers. They haven't required any regeneration switch in 9 months, although Sam says they were designed for interchange about every month. I'd like to get in there next shut-down and see what's wrong.

Jerry: Before we do that step, let's analyze the system thoroughly. It's pretty expensive to tear into a unit.

Now, I need some refreshers. What does the flowsheet of this unit look like? Sam I asked you to be here since you helped design this unit. Would you explain the details?

Sam: Here's the simplified flowsheet. The propane and purified chloro-propane mixture is flashed to get depropanized chloro-propane. This is sent to a dehydrogenation and then propyl alcohol reactor to prepare the alcohol for sale.

Since hydrocarbon and chlorine storage accumulates water from air leaks, etc., the driers were added to remove this dissolved water since the dehydrogenation catalyst is very water sensitive. The driers adsorb H_2O in the molecular-sieve packed bed. One drier is regenerated, while the other becomes saturated with H_2O. When this happens, the valving is switched so the regenerated bed is now used to adsorb the water. This can be accomplished and still maintain a continuous flow system.

Jerry: How much water is dissolved in the storage tanks anyway? Maybe there's not enough water to worry about.

Sam: No, if equilibrium is reached, the solubility limits are 100 ppm (wt%) for air at 100% humidity water vapor @ 25°C. Chlorine usually has about 20 ppm (wt%).

Jerry: Is equilibrium reached?

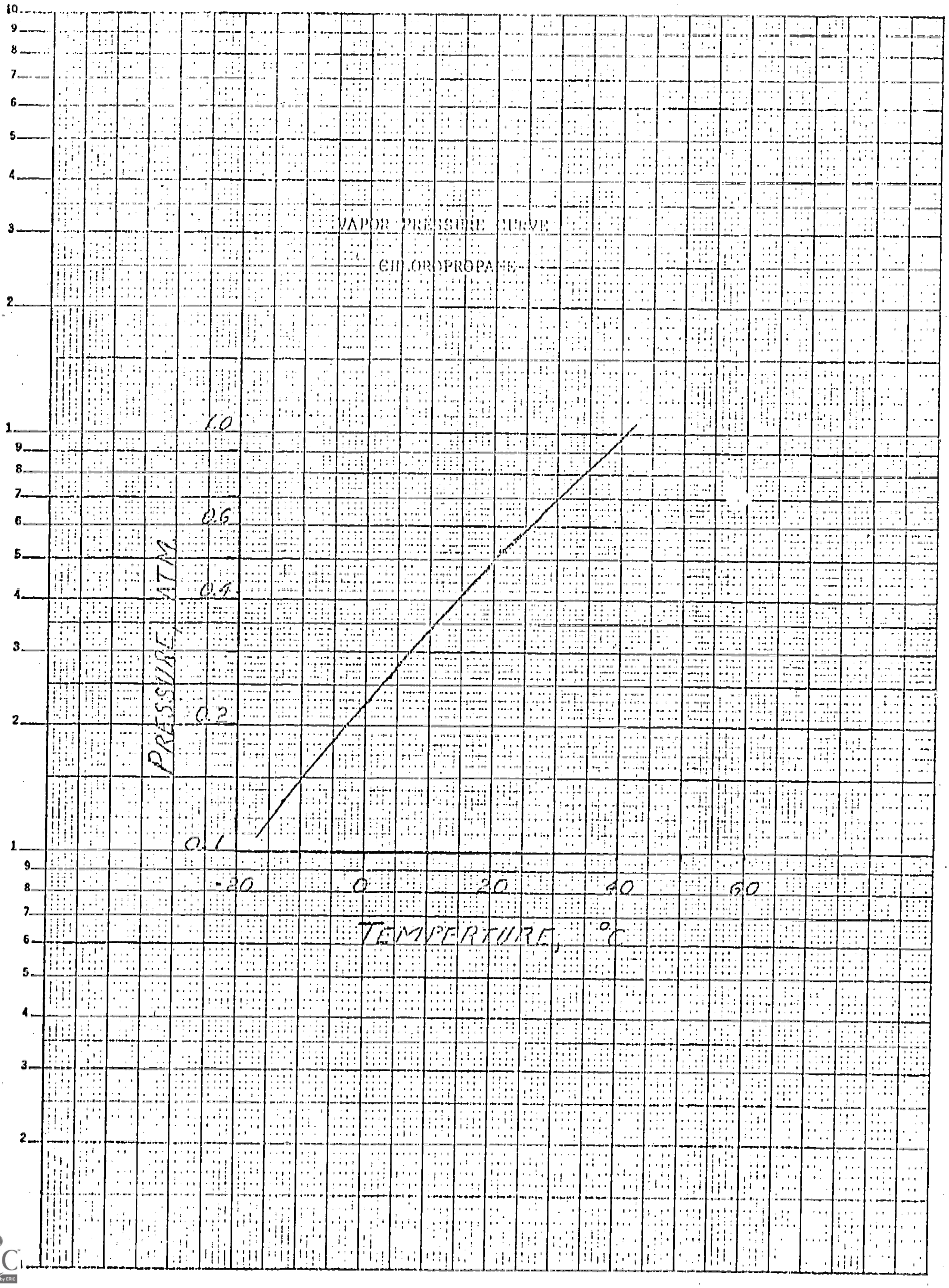
Jim: Not quite, tests from the storage tank the last three days have shown 58 ppm, 62 ppm, 61 ppm. The chlorine has contained the 20 ppm.

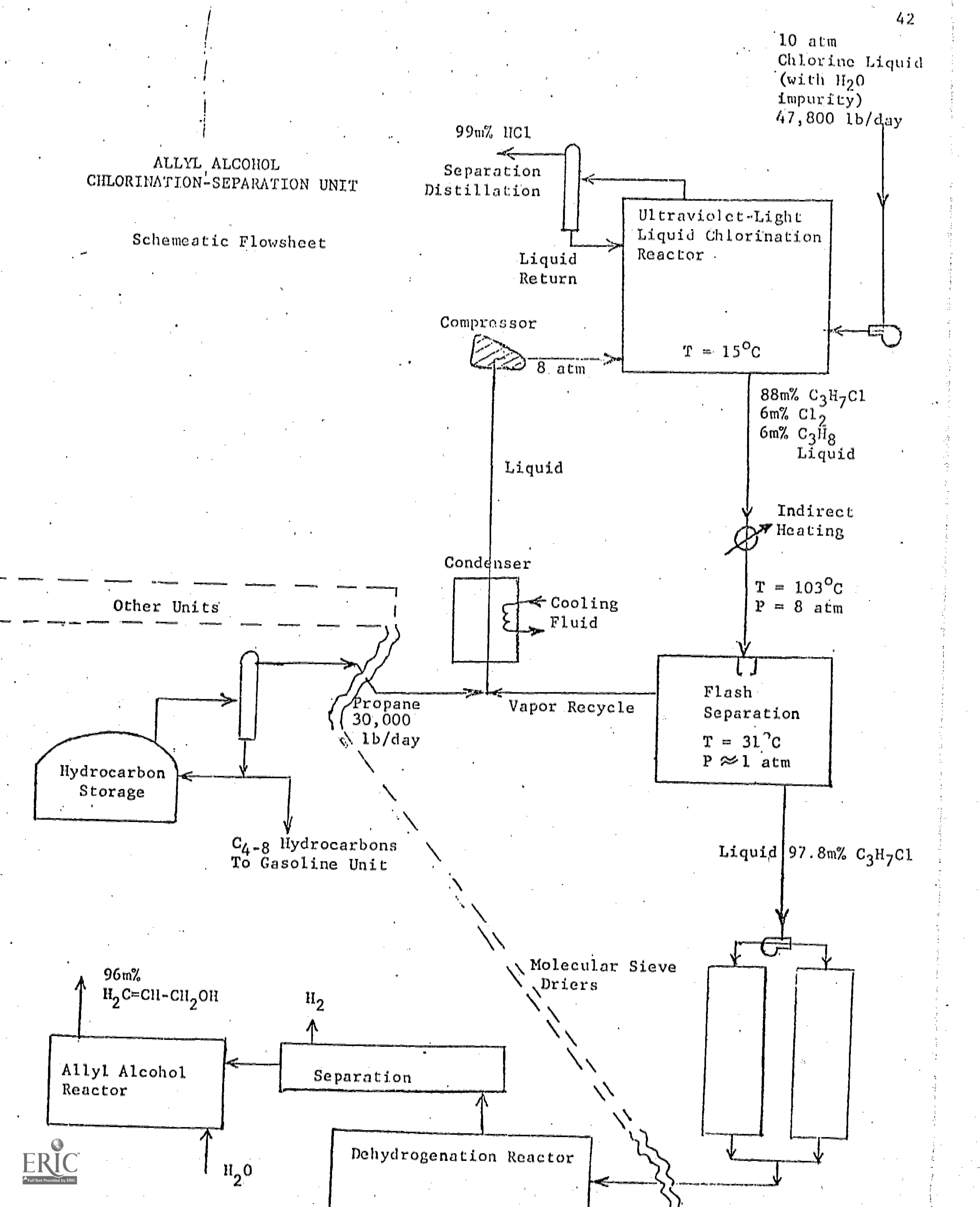
Sam: That's high enough. Probably it is just an indication of the normal relative humidity in air.

Jim: What happens to the catalyst if there's too much water? Could the molecular sieves be inadequate, but the effect of water isn't that important?

Sam: No, if the water limits are exceeded by much, the catalyst becomes poisoned as the H_2O is preferentially adsorbed and the conversion of chloro-propane to chloro-propene drops from 99% efficiency to about 50% efficiency in a matter of days.

Jerry: Well, it appears something is funny. It should be looked into, although it is not critical since the system has been on-stream and operating very well for these 9 months since start-up. I don't like opening up the driers and hope it isn't required. Jim, why don't you check the design calculations and then recommend a course of action.


VAPOR PRESSURE CURVE
CHLOROPROPANE
PRESSURE, ATM
1.0
0.6
0.4
0.2
0.1
-20
0
20
40
60
TEMPERTURE, °C



ALLYL ALCOHOL
CHLORINATION-SEPARATION UNIT
Schemeatic Flowsheet
10 atm
Chlorine Liquid
(with H2O
impurity)
47,800 lb/day
99m% HCl
Separation
Distillation
Ultraviolet-Light
Liquid Chlorination
Reactor
T = 15°C
Liquid
Return
Compressor
8 atm
88m% C3H7Cl
6m% Cl2
6m% C3H8
Liquid
Liquid
Indirect
Heating
Condenser
T = 103°C
P = 8 atm
Other Units
Cooling
Fluid
Flash
Separation
T = 31°C
P ≈ 1 atm
Propane
30,000
lb/day
Vapor Recycle
Hydrocarbon
Storage
C4-8 Hydrocarbons
To Gasoline Unit
Liquid
97.8m% C3H7Cl
Molecular Sieve
Driers
96m%
H2C=CH-CH2OH
H2
Allyl Alcohol
Reactor
Separation
Dehydrogenation Reactor
H2O

INFORMATION DETAIL
Allyl Alcohol Chlorination Separation Unit

Molecular Sieve Driers

Each, 100 lb. H_2O adsorption capacity

$T = 31^\circ C$

Flash Separation Unit

Major Constituents, Liquid Product

97.8m% C_3H_7Cl

1m% C_3H_8

1.2m% Cl_2

Chlorination Reactor HCl - Vapor Overhead Stream

Distillation Feed 80m% HCl

Cl_2, C_3H_8, Impurities

Product 99m% HCl

Cl_2, C_3H_8, Impurities

Chlorination Reactor:

Reaction: $C_3H_8 + Cl_2 \xrightarrow{U.V.} C_2H_5CH_2Cl + Cl_2$ (Only reaction to be considered)

Deyhdrogenation Reactor

Reaction, Using Catalyst "A":

$C_3H_7Cl \xrightarrow{\Delta} H_2C = CH - CH_2Cl + H_2$

Allyl Alcohol Reaction

Reaction, Using Catalyst "B"

$C_2H = CH - CH_2Cl + H_2 \xrightarrow{250^\circ C} C_2H = CH - CH_2OH + HCl$

SOLAR ENERGY PACKET

Submitted to - FTE Corporation
Morgantown, W.Va.

by- Monchesen-Junior Co.
West Virginia University
Morgantown, W.Va.

Abstract

Investigating the feasibility of developing individual power packs, capable of delivering 20 kilowatts over an eight hour period in the desert regions of Nevada, using solar energy, it has been found that such a power pack can be built, employing a parabolic mirror assembly and a black body heat exchanger in conjunction with a small turbine and other supporting equipment, as described herein. After consideration of various heat transfer fluids for use in the system, the fluorocarbon, dicloro-difluoromethane (produced by E.I. DuPont & Co. under the registered trade name Freon 12) was adopted for the power pack. Total plant efficiency for the proposed system is low and has been approximated at 7.5%.

Objectives

The basic objective of this report is to outline the flow system of the proposed power pack; that is, to explain why this system has been adopted in preference to other systems and what considerations have been selectively included in the basic design.

Design Procedure
~~Experimental~~

Several consideratins have been made in the selection of a heat transfer fluid. The most important of these include its heat capacity over the temperatures used, the relative size of its enthalpy dome, its characteristic vapor pressure at the upper temperature, and its critical temperature and pressure. These factors will be discussed in some detail; however, various considerations of lesser importance such as toxicity, cost, relative availability, chemical stability, and general handling problems of the selected fluid were applicable, but will not be documented here.

The heat capacity of the fluid has been considered in an attempt to optimize two effects. If the heat capacity is large, the efficiency of the plant will be lower; however, if the heat capacity is small, the increased bulk of the equipment used in the process will proportionally dilate the initial construction costs.

The relative size of the enthalpy dome is pertinent because in the liquid - gas system the fluid must be condensed. If the enthalpy dome is wide in this region, a great deal of work will be expended removing this heat which here again will cut down plant efficiency. In an attempt to avoid this, it has been elected to operate close to the critical point where the dome is at a minimum width.

The turbine is more efficient at higher pressure and since the fluid enters the turbine under its own vapor pressure, it was desirable that the fluid must have a reasonably high vapor pressure.

The most important fluids considered for the system are the following: ammonia, carbon disulfide, Freon 11, Freon 12, Freon 13, Genetron 21, Freon 114, and water. After a review of all available data, with respect to the various considerations described above, it was decided that Freon 12 (dichlorodifluoromethane) would best suit the needs of this system. Support for your idea; should have explanation.

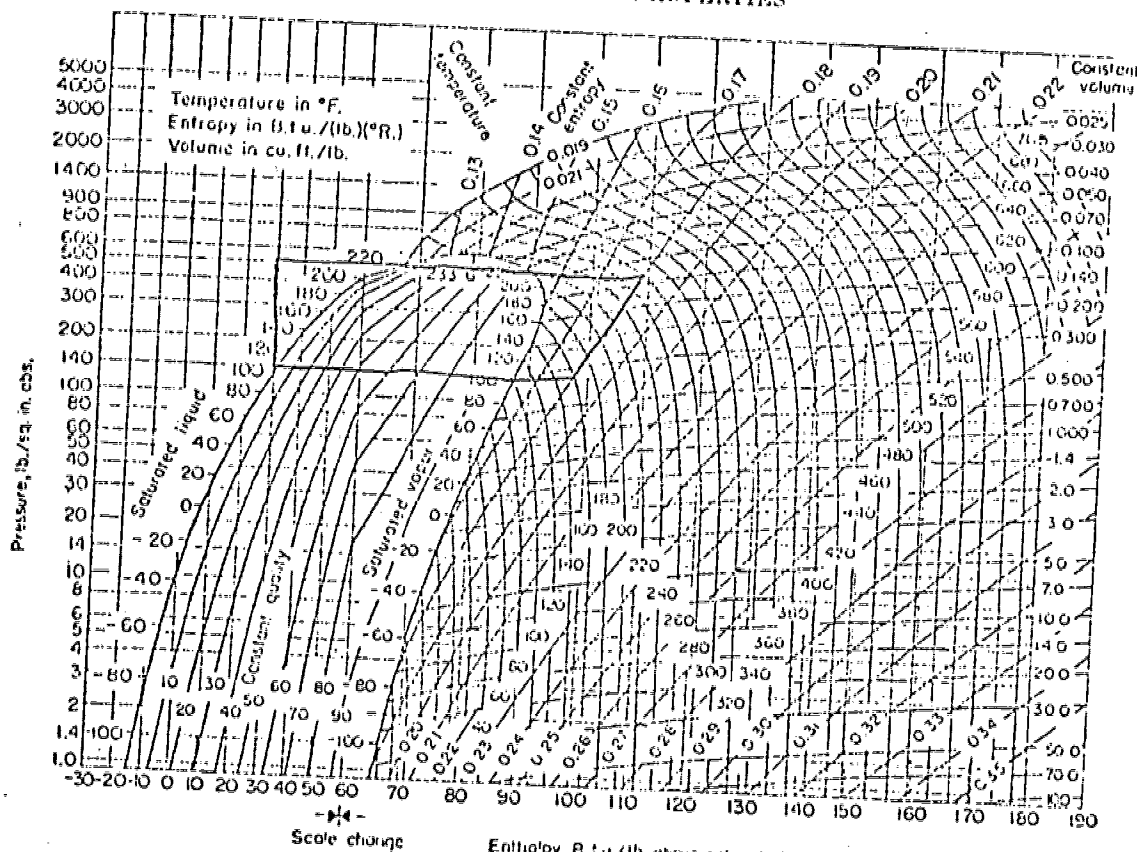


FIG. 3-24. Pressure-enthalpy diagram for Freon-12 refrigerant. (*Copyright 1956 by E. I. du Pont de Nemours & Co., Inc. Reprinted by permission.*) For a description of the experimental work and procedures used to calculate these data see McHarness, Eiseman, *et al.*, *Refrig. Eng.*, 63, 31 (1955); see also Martin, "Thermodynamic and Transport Properties of Gases, Liquids and Solids," p. 110, A.S.M.E., New York, 1959. A publication "Thermodynamic Properties of Freon 12," E. I. du Pont de Nemours & Co., Inc., undated, reproduces the same diagram and tabular data to 600 lb./sq. in. abs. Apparently, tabular data above 600 lb./sq. in. abs. are not available.

Table 3-237. Saturated Freon-12 (Dichlorodifluoromethane)*

Temp., °F. t	Abs. pressure, lb./sq. in. p	Volume, cu. ft./lb. Liquid v_f	Volume, cu. ft./lb. Vapor v_g	Enthalpy, B.t.u./lb. Liquid h_f	Enthalpy, B.t.u./lb. Vapor h_g	Entropy, B.t.u./(lb.)(°R.) Liquid s_f	Entropy, B.t.u./(lb.)(°R.) Vapor s_g	Temp., °F. t	Abs. pressure, lb./sq. in. p	Volume, cu. ft./lb. Liquid v_f	Volume, cu. ft./lb. Vapor v_g	Enthalpy, B.t.u./lb. Liquid h_f	Enthalpy, B.t.u./lb. Vapor h_g	Entropy, B.t.u./(lb.)(°R.) Liquid s_f	Entropy, B.t.u./(lb.)(°R.) Vapor s_g
−40	9.32	0.0106	3.911	0	73.50	0	0.17517	32	44.77	.0115	.906	15.21	81.63	.03123	.16976
−30	12.02	.0107	3.088	2.03	74.70	0.00471	.17367	36	48.13	.0116	.818	16.10	82.27	.03302	.16954
−20	15.28	.0108	2.474	4.07	75.87	.00740	.17275	40	51.68	.0116	.792	17.01	82.71	.03480	.16833
−16	16.77	.0108	2.271	4.89	76.34	.01126	.17232	50	61.39	.0118	.673	19.27	83.78	.03916	.16785
−12	18.37	.0109	2.058	5.72	76.81	.01310	.17124	60	72.41	.0119	.575	21.57	84.82	.04369	.16741
− 8	20.08	.0109	1.922	6.57	77.29	.01406	.17158	70	84.82	.0121	.493	23.90	85.82	.04797	.16701
− 4	21.91	.0110	1.772	7.41	77.75	.01682	.17125	80	98.76	.0123	.425	26.23	86.80	.05216	.16662
0	23.87	.0110	1.637	8.25	78.21	.01869	.17091	90	114.3	.0125	.368	28.70	87.74	.05632	.16621
+ 4	25.96	.0111	1.514	9.10	78.67	.02032	.17060	100	131.6	.0127	.319	31.16	88.62	.06316	.16584
8	28.13	.0111	1.403	9.96	79.13	.02215	.17030	110	150.7	.0129	.277	33.65	89.43	.06719	.16542
12	30.56	.0112	1.301	10.82	79.59	.02419	.17001	120	171.8	.0132	.240	36.16	90.15	.07150	.16495
16	33.08	.0112	1.207	11.70	80.05	.02601	.16974	130	194.9	.0134	.208	38.69	90.76	.07607	.16438
20	35.75	.0113	1.121	12.55	80.49	.02763	.16949	140	220.2	.0138	.180	41.24	91.24	.08024	.16363
24	38.58	.0113	1.011	13.44	80.95	.02943	.16926								
28	41.59	.0114	0.973	14.32	81.39	.03111	.16904								

* From *Am. Soc. Refrig. Eng. Circ.* 12, by permission. Newer tables issued by E. I. du Pont de Nemours Co., Inc., show some differences.

Results

The proposed flow system that has been developed is one that contains a compressor, a reflector unit, a small turbine unit, and a blower heat exchanger. The electrical power will be stored by a nickel - cadmium battery system. The calculated efficiency of the plant process was 7.5%. The results of the design for the greatest efficiencies of each stage were as follows.

Based on a 85% compressor efficiency, the work calculated when 1lb. of Freon 12 at a temperature of 100 F is is compressed from 140 lb/in^2 to a pressure of 500 lb/in^2 is 1.00 BTU/lb. Using a 120 lb cycle operation system and a cycle rate of 1 cycle/min for a 10 hour day - the total work done by the compressor is 72,000 BTU/day.

Low

Should have higher P,T upper, as discussed in class one can go above critical point

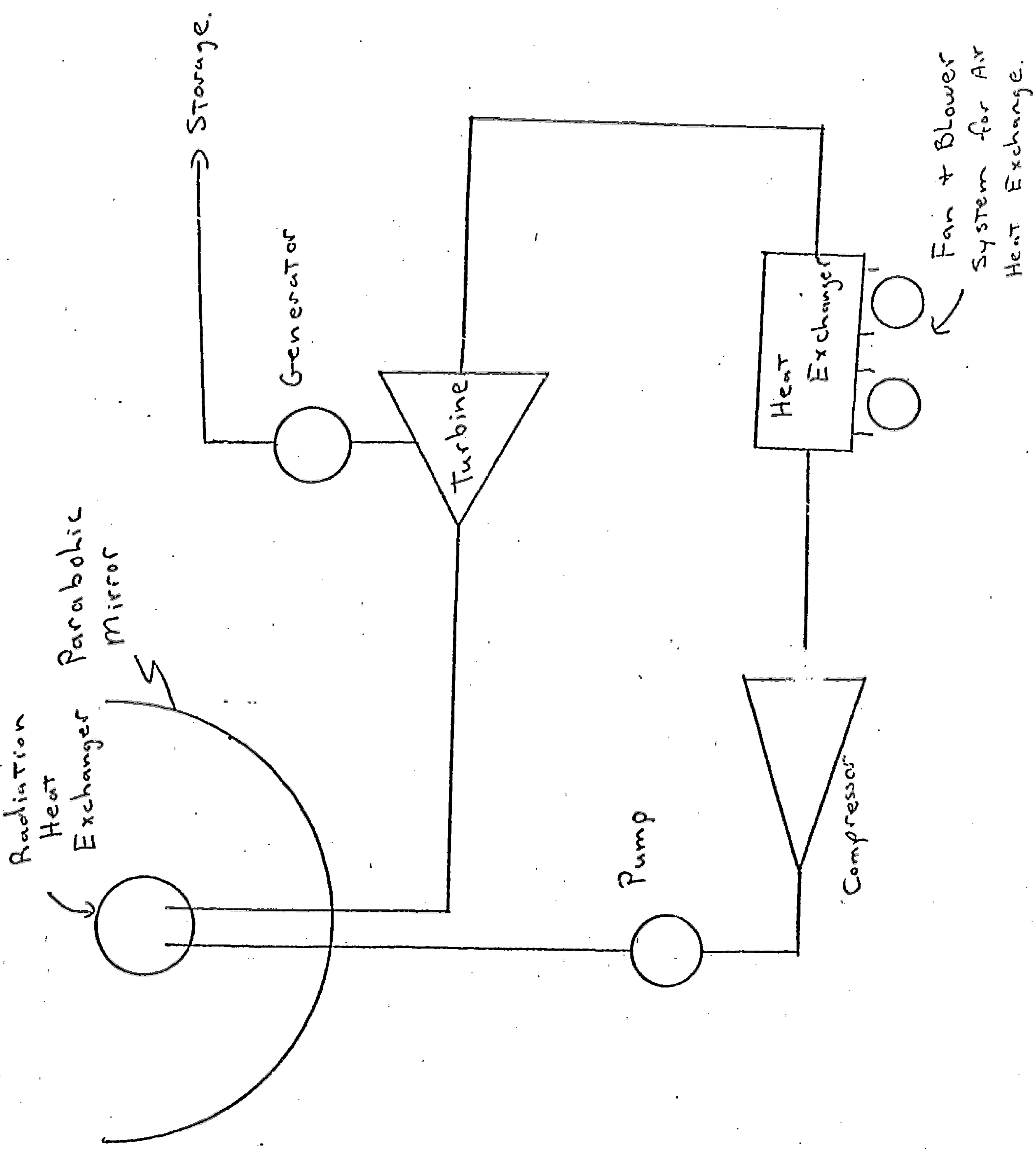
The heat added in raising the Freon to 280 F by the sun reflector is 120 BTU/lb or the total heat added for a 120 lb operation is 8,640,000 BTU/day, assuming the mirror system to be 90% efficient.

The efficiency of the turbine and the exchanger together willbe taken to be 75%. The heated Freon is fed to the turbine where it is expanded to a pressure of 144 lb/in^2 at a temperature of 150 F. The work obtained from this expansion is 9 BTU/lb. and the 10 hour total work is 648,000 BTU.

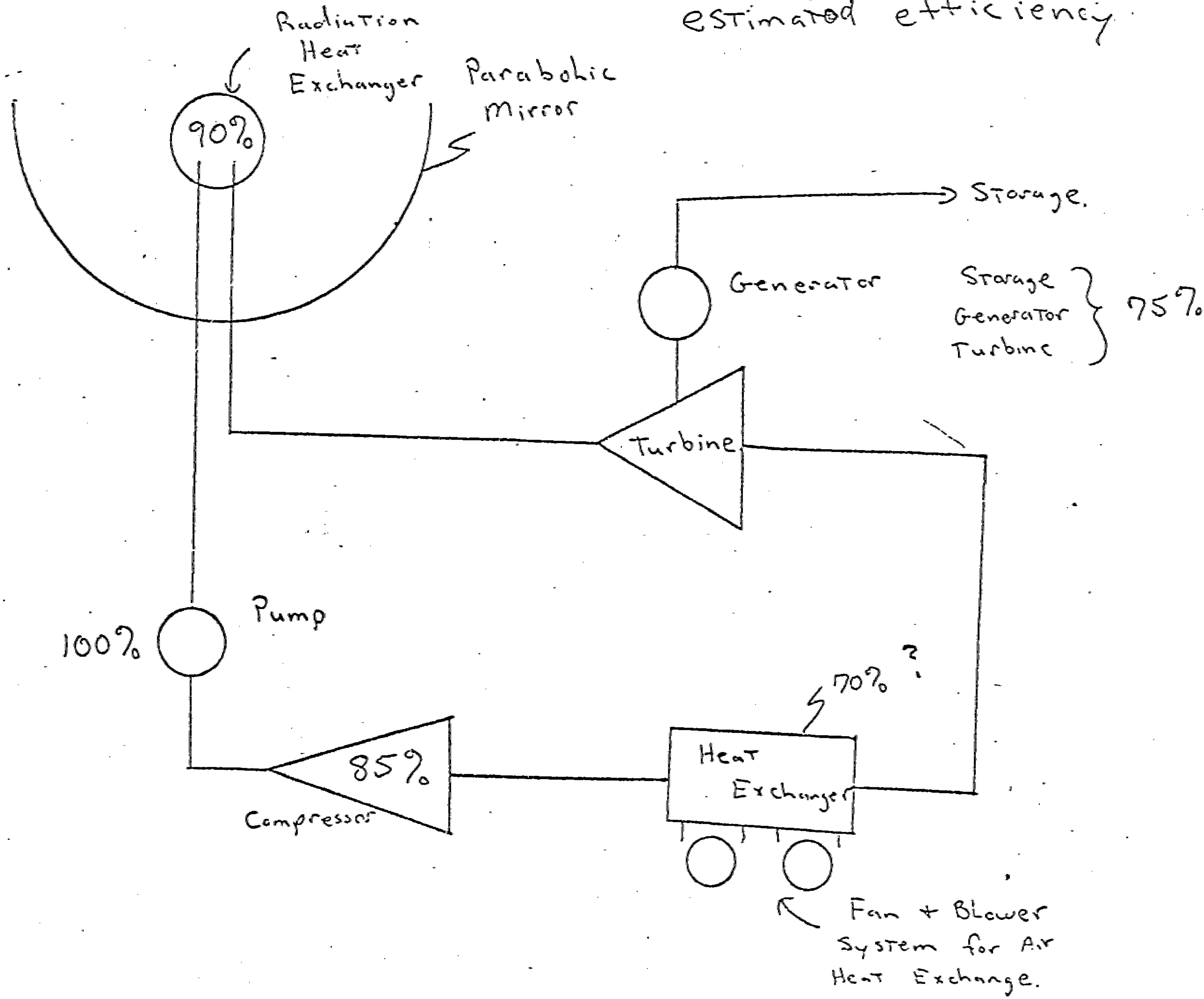
The Freon enters the heat exchanger at 140 F and at a pressure of 144 lb/in^2. The heat removed

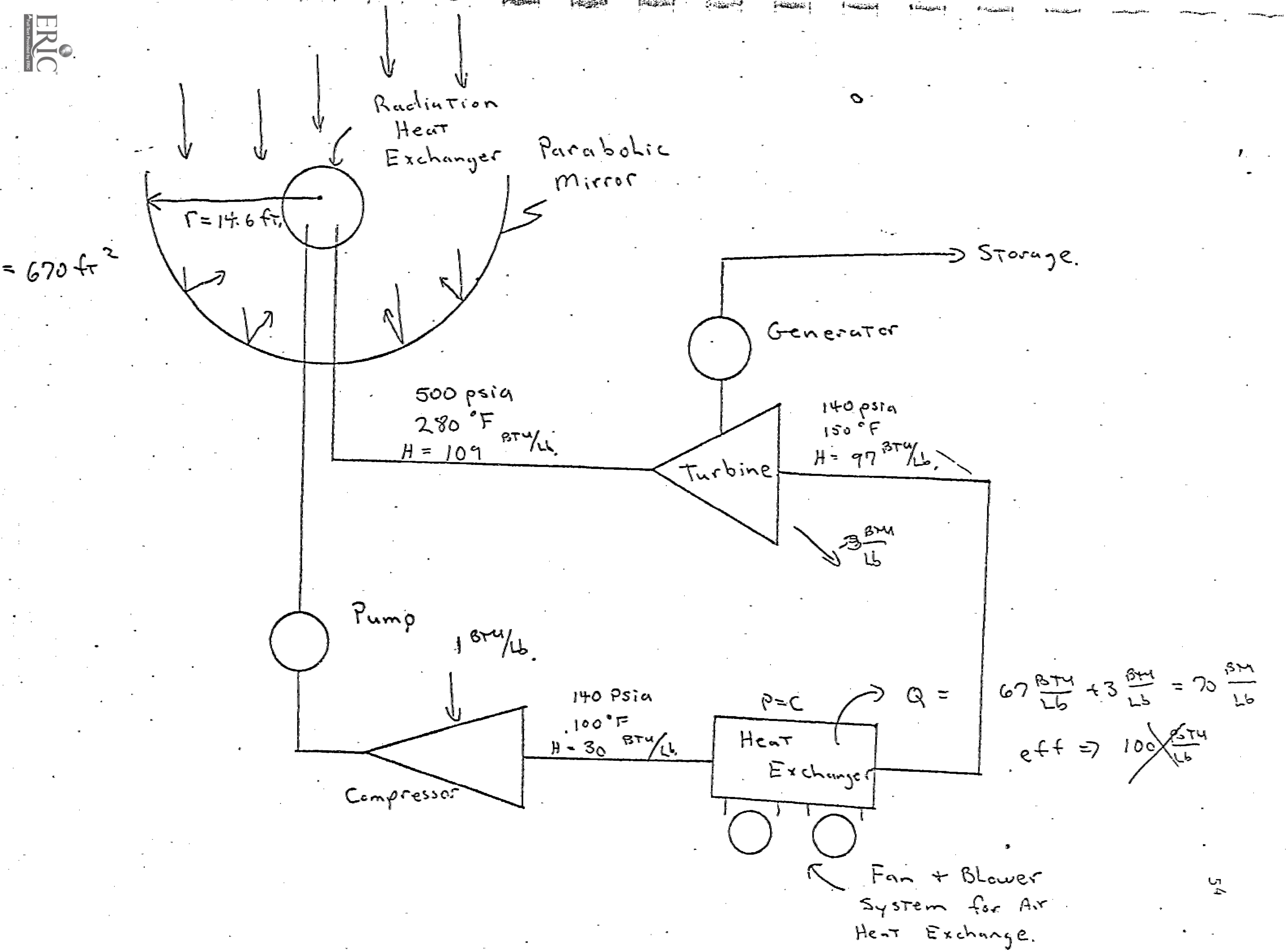
70

by the air fan system is 100 BTU/lb and the total heat removal for 10 hours is 7,200,000 BTU/day.


Storage
Generator
Turbine
Heat Exchanger
Fan + Blower System for Air Heat Exchange.
Parabolic Mirror
Radiation Heat Exchanger
Pump
Compressor

estimated efficiency




Radiation Heat Exchanger
Parabolic Mirror
r = 14.6 ft.
= 670 ft²
Storage.
Generator
500 psia
280 °F
H = 109 BTU/Lb.
140 psia
150 °F
H = 97 BTU/Lb.
Turbine
-3 BTU/Lb
Pump
1 BTU/Lb.
140 Psia
100 °F
H - 30 BTU/Lb.
Compressor
P=C
Heat Exchanger
Q = 67 BTU/Lb + 3 BTU/Lb = 70 BTU/Lb
eff => 100 BTU/Lb
Fan + Blower System for Air Heat Exchange.

CALCULATIONS:

Should be in Appendix

WORK DONE BY COMPRESSOR

$$W = -\int_{P_1}^{P_2} V\,dP$$

$P_1 = 140$ psia
$P_2 = 500$ psia
$V = .0129\ ft^3/lb$

$$W = \left(.0129\ ft^3\right)\left[(500-140)\,lb/in^2\right]\left(\frac{144\ in^2}{1\ ft^2}\right)\left(\frac{1\ ft\text{-}lb}{778\ Btu}\right)$$

$W = 0.86$ Btu

ASSUME 85 % EFFICIENT $\Rightarrow$ $\boxed{W = -1.0\ Btu/lb}$

WORK OBTAINED BY TURBINE

$$W = -\Delta H$$

	PRESSURE	TEMPERATURE	ENTHALPY
(1)	500 lb/in^2	150 °F	109 Btu/lb
(2)	140 lb/in^2	280 °F	97 Btu/lb

$W = -(97 - 109)$ Btu/lb

$W = 12$ Btu/lb

ASSUME 75 % EFFICIENT $\Rightarrow$ $\boxed{W = +9\ Btu/lb}$

$\Rightarrow$ 3 Btu/lb goes to heating up compressor which
$\Rightarrow$ 3 Btu/lb MUST ALSO BE TAKEN WITH HEAT EXCHANGER

HEAT REMOVED BY HEAT EXCHANGER

$$Q - \cancel{W}^{\,0} = +\Delta H$$

$Q = +(30 - 97) = 67$ Btu/lb

	PRESSURE	TEMPERATURE	ENTHALPY
(1)	140 lb/in^2	150 °F	97 Btu/lb
(2)	140 lb/in^2	100 °F	30 Btu/lb

?

$Q_{total} = (67 + 3)$ Btu/lb $= 70$ Btu/lb

ASSUME 70 % EFFICIENT $\Rightarrow$ $\boxed{Q = 70/.7 = 100 \text{ Btu that must be removed}}$

?

CALCULATIONS (CONT.):

DETERMINING SIZE OF MIRROR

REQUIRED HEAT FROM SUN — 546080 Btu
SUNS RADIATION ENERGY — 816 Btu/ft²·hr

AREA of MIRROR = $\dfrac{546{,}080 \text{ Btu}}{816 \text{ Btu/ft}^2\cdot\text{hr?}}$ = 670 ft² X

work ?

Efficiency of System

CALCULATIONS FOR HEAT REQUIRED from SUN PER lb OF FREON 12

$(Q)(eff_S) = (\text{heat taken away by heat Ex.})/(eff_H) + (\text{work obtained from Generator})(eff_G)$

heat taken away by heat exchanger = 70 Btu/lb

work obtained from turbine = (9-1) = 8 Btu/lb

1 Btu/lb — runs fan for heat Ex.

eff_S = efficiency of sun reflecting unit — .90

Q = Heat required from sun/lb of Freon

eff_H = efficiency of heat exchanger — .70

eff_G = efficiency of Generator — 1.00

$Q(.90) = (70 \text{ Btu/lb})/.70 + (8 \text{ Btu/lb})(1.00)$

$\boxed{Q = 120 \text{ Btu/lb of HEAT FROM SUN}}$

86

DETERMINING NUMBER OF CYCLES REQUIRED PER DAY

$(8 \text{ Btu/lb})(120 \text{ lb of Freon}/\text{lb mole Freon}) = 960 \text{ Btu/lb mole}$

NUMBER CYCLES REQUIRED = $\dfrac{546080 \text{ Btu}}{960}$ = 569 $\dfrac{\text{cycles}}{\text{day}}$ ≈ 57 $\dfrac{\text{cycles}}{\text{hr}}$ = $\dfrac{\text{7lb mole}}{\text{min}}$

IF assume 600 cycles/day ⇒ that the extra 32 cycles or 11 K.W.H could be allowed to run for heat exchanger.

Discussion

In drafting the design of a power plant which is to operate on solar energy, the energy of the sun's rays is concentrated using parabolic mirrors in coordination with a black body heat exchanger. During a ten hour operation day, 160 KWH of power is stored employing a nickle - cadmium battery system. Due to the size and cost differences, this system was selected in deference to a proposed capacitor system. Following analysis of the intrinsic seasonal disparities in the available solar energy, an average energy maximum and minimum of 1800 BTU/ft^2 hr^{-1} and 891 BTU/ft^2 respectively were determined for the system in the arid Nevada region. The plant is designed to operate as specified at the minimum radiation level. This implies that during the summer months of maximum radiation, a sufficient excess of power is produced such that either the daily operation could be curtailed after about five hours or the excess could be stored in a specifically adapted secondary battery system, allowing subsequent withdrawal on days of uncommonly lower solar radiation.

The system incorporates an adiabatic turbine as well as a compressor system and two isobaric heat exchangers. One of the heat exchangers is heated by the sun and the second is cooled by a blower fan type mechanism, using air as the second fluid. Thus heat is expelled into the atmosphere.

To produce the amount of electricity required, a direct current generator is used, because if an alternating current generator is employed a rectifying system would have to be purchased in order to store the electricity in the batteries. For 160 KWH of electricity to be generated, 561 cycles of the system is required daily, with one pound mole of Freon 12 in each cycle. Employing a 600 cycle per day or one pound mole per minute use of Freon 12, the work day was designated at ten hours, and the excess power produced being used to operate the fan mechanism, the liquid Freon pump, and various other electrical requirements of the plant.

The possible source of errors encountered in the designing may be in assumed efficiencies of the components of the system, although these efficiencies were assumed lower than the normal values to allow for such possible errors. It was also assumed that the electricity to run the secondary heat exchanger fan was small compared to a conventional refrigeration system, and the work required to operate such a system.

Conclusion

It is concluded from this design that a power plant can produce electricity from solar energy. The design has no raw materials except air and the Freon 12, and is very stable and has a long life span. The heat exchanger has no costly refrigeration system which would increase the initial cost of the plant, and little maintainance cost for the system. The design allows for weather factors and is self-sustaining. Thus, the design proposed meets thw specifications required. [For more accurate data, a pilot plant should be constructed to supply such desired information.]

probably goes better in recommend.

Good

RECOMENDATIONS

It is the opinion of this firm that,while the proposed plant will provide the power specified ,it is not an efficient method of producing that power as compared with other sources of power in the area. It is felt that the initial costs would be so great and the efficiency so low (less than 10%) in conjuntion with the possible technical difficulties having to with several assumtions and estimations that were made in the design that before any action is taken,inthe eventuality that such a plant is built, further studies be made. The major areas of this study should include,total energy availabłe from the sun, the use of an air heat exchanger and the fluid used in this process.

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Appendix III.

Instrument Samples

Samples of the Instruments
- Osgood's Semantic Differential
- Achievement Anxiety Test
- Rotter's External-Internal Locus of Control

Edward's Personal Preference Scehedule Need for Achievement
Is Copyrighted and Published .

DIRECTIONS:

Certain ideas mean different things to different people. This scale consists of six concepts (change, thinking, engineering, future goal, instruction, and peers). Think of each concept as a continuum running from one descriptive word to its opposite. There are six descriptions to be made for each concept. Please indicate what these concepts mean to you by placing an X in the box of the continuum which most closely resembles the meaning of the concepts to you. If you feel that the concept is closely related to either end of the continuum, place the X in the box on the appropriate end. Moving the X toward the middle box indicates that the concept you are rating is less related to one of the descriptive words at the ends and going in the neutral direction. An X in the middle box would, therefore, indicate that the concept is neutral or equally related to each of the descriptive words.

Please check all the items and give your first impression as soon as you are sure you understand the description of the concept.

EXAMPLE

Father

Fair_____:__X__:_____:_____:_____:_____:_____ Unfair

Future Goal

bad	___:___:___:___:___:___:___	good
colorful	___:___:___:___:___:___:___	colorless
unsuccessful	___:___:___:___:___:___:___	successful
weak	___:___:___:___:___:___:___	strong
wise	___:___:___:___:___:___:___	foolish
hard	___:___:___:___:___:___:___	soft

Instruction

colorless	___:___:___:___:___:___:___	colorful
unimportant	___:___:___:___:___:___:___	important
good	___:___:___:___:___:___:___	bad
active	___:___:___:___:___:___:___	passive
fast	___:___:___:___:___:___:___	slow
strong	___:___:___:___:___:___:___	weak

Peers

weak	___:___:___:___:___:___:___	strong
calm	___:___:___:___:___:___:___	excitable
important	___:___:___:___:___:___:___	unimportant
kind	___:___:___:___:___:___:___	cruel
foolish	___:___:___:___:___:___:___	wise
active	___:___:___:___:___:___:___	passive

Change

important	___:___:___:___:___:___:___	unimportant
bad	___:___:___:___:___:___:___	good
ugly	___:___:___:___:___:___:___	beautiful
active	___:___:___:___:___:___:___	passive
slow	___:___:___:___:___:___:___	fast
strong	___:___:___:___:___:___:___	weak

Thinking

good	___:___:___:___:___:___:___	bad
wise	___:___:___:___:___:___:___	foolish
active	___:___:___:___:___:___:___	passive
strong	___:___:___:___:___:___:___	weak
soft	___:___:___:___:___:___:___	hard
unimportant	___:___:___:___:___:___:___	important

Engineer

passive	___:___:___:___:___:___:___	active
fast	___:___:___:___:___:___:___	slow
kind	___:___:___:___:___:___:___	cruel
weak	___:___:___:___:___:___:___	strong
colorless	___:___:___:___:___:___:___	colorful
masculine	___:___:___:___:___:___:___	feminine

Please do not spend too much time on the following items. There are no right or wrong answers and therefore your first response is important. Mark T for true and F for false. Be sure to answer every question.

1. A problem has little attraction for me if I don't think it has a solution. T F

2. I am just a little uncomfortable with people unless I feel that I can understand their behavior. T F

3. There's a right way and a wrong way to do almost everything. T F

4. I would rather bet 1 to 6 on a long shot than 3 to 1 on a probable winner. T F

5. The way to understand complex problems is to be concerned with their larger aspects instead of breaking them into smaller pieces. T F

6. I get pretty anxious when I'm in a social situation over which I have no control. T F

7. Practically every problem has a solution. T F

8. It bothers me when I am unable to follow another person's train of thought. T F

9. I have always felt that there is a clear difference between right and wrong. T F

10. It bothers me when I don't know how other people react to me. T F

11. Nothing gets accomplished in this world unless you stick to some basic rules. T F

12. If I were a doctor, I would prefer the uncertainties of a psychiatrist to the clear and definite work of someone like a surgeon or X-ray specialist. T F

13. Vague and impressionistic pictures really have little appeal for me. T F

14. If I were a scientist, it would bother me that my work would never be completed (because science will always make new discoveries). T F

15. Before an examination, I feel much less anxious if I know how many questions there will be. T F

16. The best part of working a jigsaw puzzle is putting in that last piece. T F

17. Sometimes I rather enjoy going against the rules and doing things I'm not supposed to do. T F

18. I don't like to work on a problem unless there is a possibility of coming out with a clear-cut and unambiguous answer. T F

19. I like to fool around with new ideas, even if they turn out later to be a total waste of time. T F

20. Perfect balance is the essence of all good composition. T F

AAT QUESTIONNAIRE

Name: ______________________
please print

This is not a test. There are no right or wrong answers to the questions below. Each of the following questions has five alternatives, and you are supposed to select one of them. Please read each question carefully and put a mark (X) in the pair of parentheses to the left of the alternative which you think best represents you. Please answer all the questions.

1. Nervousness while taking an exam or test hinders me from doing well.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

2. I work most effectively under pressure, as when the task is very important.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

3. In a course where I have been doing poorly, my fear of a bad grade cuts down my efficiency.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Always

4. When I am poorly prepared for an exam or test, I get upset, and do less well than even my restricted knowledge should allow.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Always

5. The more important the examination, the less well I seem to do.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

6. While I may (or may not) be nervous before taking an exam, once I start, I seem to forget to be nervous.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

7. During exams or tests, I block on questions to which I know the answers, even though I might remember them as soon as the exam is over.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

8. Nervousness while taking a test helps me do better.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Always

9. When I start a test, nothing is able to distract me.

( ) This is always true of me
( ) This is frequently true of me
( ) This is sometimes true of me
( ) This is rarely true of me
( ) This is not true of me

10. I find that my mind goes blank at the beginning of an exam, and it takes me a few minutes before I can function.

( ) I almost always blank out at first
( ) I frequently blank out at first
( ) I sometimes blank out at first
( ) I rarely blank out at first
( ) I never blank out at first

11. In courses in which the total grade is based mainly on one exam, I seem to do better than other people.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Always

12. I look forward to exams.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Always

13. I am so tired from worrying about an exam, that I find I almost don't care how well I do by the time I start the test.

( ) I never feel this way
( ) I rarely feel this way
( ) I sometimes feel this way
( ) I frequently feel this way
( ) I almost always feel this way

14. Time pressure on an exam causes me to do worse than the rest of the group under similar conditions.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

15. Although "cramming" under pre-examination tension is not effective for most people, I find that if the need arises, I can learn material immediately before an exam, even under considerable pressure, and successfully retain it to use on the exam.

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

16. I enjoy taking a difficult exam more than an easy one

( ) Always
( ) Frequently
( ) Sometimes
( ) Rarely
( ) Never

17. I find myself reading exam questions without understanding them, and I must go back over them so that they will make sense.

( ) Never
( ) Rarely
( ) Sometimes
( ) Frequently
( ) Almost always

18. The more important the exam or test, the better I seem to do

( ) This is always true of me
( ) This is frequently true of me
( ) This is sometimes true of me
( ) This is rarely true of me
( ) This is never true of me

19. When I don't do well on a difficult item at the beginning of an exam, it tends to upset me so that I block out even easy questions later on.

( ) This never happens to me
( ) This rarely happens to me
( ) This sometimes happens to me
( ) This frequently happens to me
( ) This almost always happens to me

SOCIAL ATTITUDE SURVEY

This is a questionnaire to find out the way in which certain important events in our society affect different people. Each item consists of a pair of alternatives lettered a or b. Please select the one statement of each pair (and only one) which you more strongly believe to be the case as far as you're concerned. Be sure to select the one you actually believe to be more true rather than the one you think you should choose or the one you would like to be true. This is a measure of personal belief; obviously there are no right or wrong answers.

Please answer these items carefully but do no spend too much time on any one item. Be sure to find an answer for every choice. Circle the letter representing the statement which you choose as the more true of the pair.

In some instances you may discover that you believe both statements or neither one. In such cases, be sure to select the one you more strongly believe to be the case as far as you're concerned. Also try to respond to each item independently when making your choice; do not be influenced by your previous choices.

1. a. Children get into trouble because their parents punish them too much.
   b. The trouble with most children nowadays in that their parents are too easy on them.

2. a. Many of the unhappy things in people's lives are partly due to bad luck
   b. People's misfortunes result from the mistakes they make.

3. a. One of the major reasons why we have wars is because people don't take enough interest in politics.
   b. There will always be wars, no matter how hard people try to prevent them.

4. a. In the long run people get the respect they deserve in this world.
   b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.

5. a. The idea that teachers are unfair to students is nonsense.
   b. Most students don't realize the extent to which their grades are influenced by accidental happenings.

6. a. Without the right breaks one cannot be an effective leader.
   b. Capable people who fail to become leaders have not taken advantage of their opportunities.

7. a. No matter how hard you try some people just don't like you.
   b. People who can't get others to like them don't understand how to get along with others.

8. a. Heredity plays the major role in determinging one's personality.
   b. It is one's experiences in life which determine what they're like.

9. a. I have often found that what is going to happen will happen.
   b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.

10. a. In the case of the well prepared student there is rarely if ever such a thing as an unfair test.
    b. Many times exam questions tend to be so unrelated to course work that studying is useless.

11. a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.
    b. Getting a good job depends mainly on being in the right place at the right time.

12. a. The average citizen can have an influence in government decisions.
    b. This world is run by the few people in power, and there is not much the little guy can do about it.

13. a. When I make plans, I am almost certain that I can make them work.
    b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

14. a. There are certain people who are just no good.
    b. There is some good in everybody.

15. a. In my case getting what I want has little or nothing to do with luck.
    b. Many times we might just as well decide what to do by flipping a coin.

16. a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.
    b. Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.

17. a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.
    b. By taking an active part in political and social affairs the people can control world events.

18. a. Most people don't realize the extent to which their lives are controlled by accidental happenings.
    b. There really is no such thing as "luck".

19. a. One should always be willing to admit mistakes.
    b. It is usually best to cover up one's mistakes.

20. a. It is hard to know whether or not a person really likes you.
    b. How many friends you have depends upon how nice a person you are.

21. a. In the long run the bad things that happen to us are balanced by the good ones.
    b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.

22. a. With enough effort we can wipe out political corruption.
    b. It is difficult for people to have much control over the things politicians do in office.

23. a. Sometimes I can't understand how teachers arrive at the grades they give.
    b. There is a direct connection between how hard I study and the grades I get.

24. a. A good leader makes it clear to everybody what their jobs are.
    b. A good leader expects people to decide for themselves what they should do.

25. a. Many times I feel that I have little influence over the things that happen to me.
    b. It is impossible for me to believe that chance or luck plays an important role in my life.

26. a. People are lonely because they don't try to be friendly.
    b. There's not much use in trying too hard to please people, if they like you, they like you.

27. a. There is too much emphasis on athletics in high school.
    b. Team sports are an excellent way to build character.

28. a. What happens to me is my own doing.
    b. Sometimes I feel that I don't have enough control over the direction my life is taking.

29. a. Most of the time I can't understand why politicians behave the way they do.
    b. In the long run the people are responsible for bad government on a national as well as on a local level.